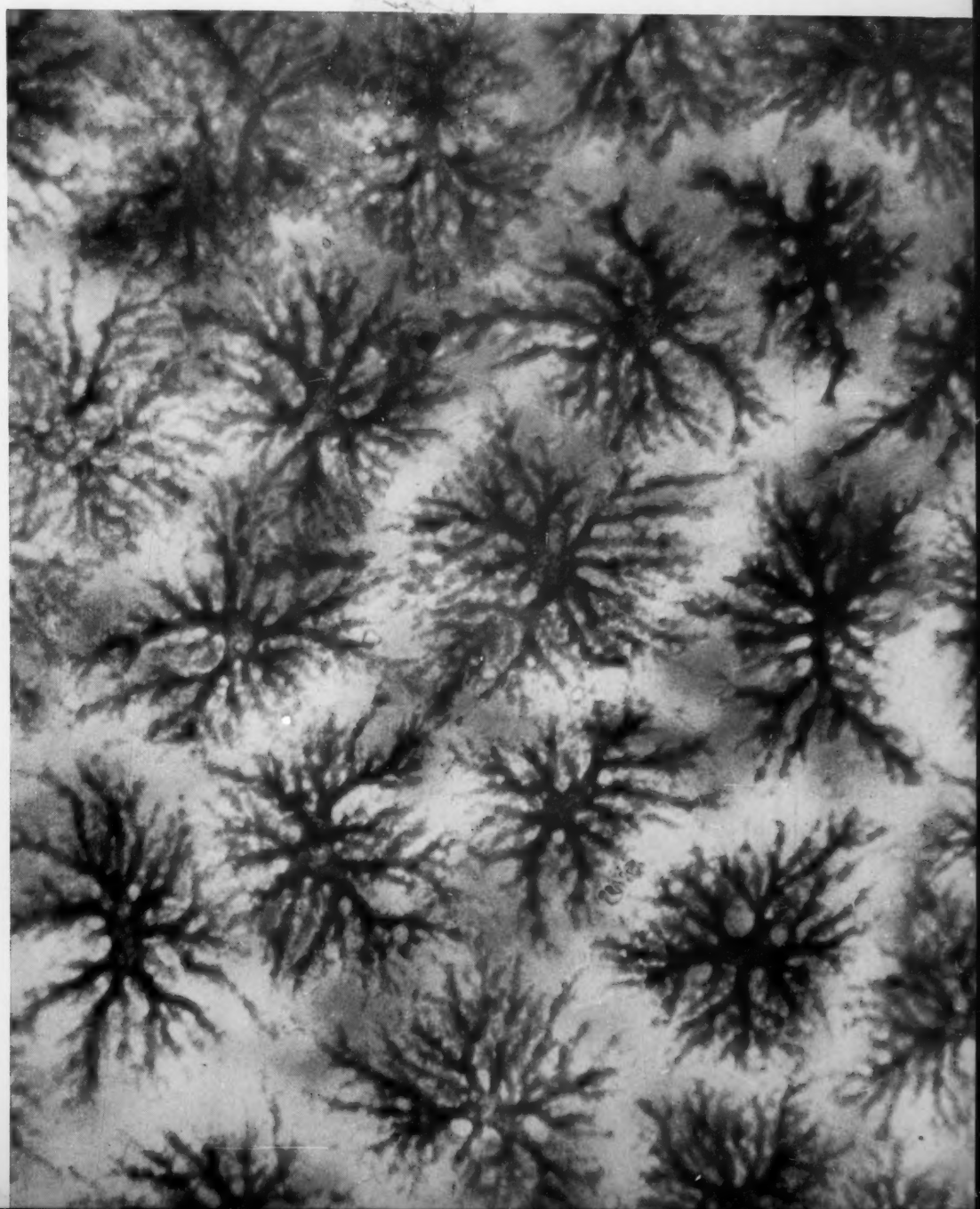
SCIENCE

18 November 1960

Vol. 132, No. 3438

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE



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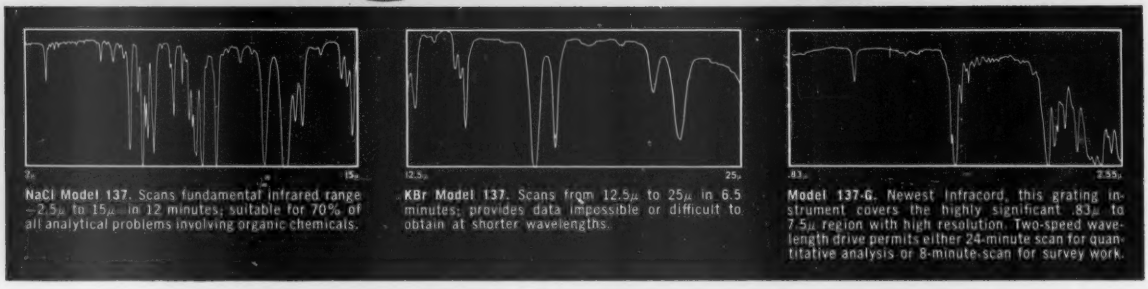

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18 November 1960, Volume 132, Number 3438

SCIENCE

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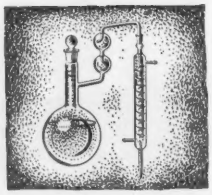
IT HAPPENED THIS MONTH...

a glance at yesterday in relation to today



IN NOVEMBER – (1910) – there is reported[1] a study of the influence of alcohol upon nitrogen metabolism in dogs and man. Moderate doses of alcohol are found to exert a protein-sparing action; with larger quantities there is some nitrogen loss. Perhaps the most significant impression is the absence of any *profound* disturbance in protein metabolism, even when comparatively large doses are continued for days and weeks.

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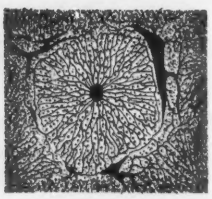

IN NOVEMBER – (1939) – a letter from the Coris[2] discusses certain apparent differences between liver, brain, and muscle phosphorylase. The liver enzyme converts glucose-1-phosphate to glycogen more rapidly than do preparations from other tissues. This is attributable to contamination of liver phosphorylase by glycogen, rather than to an intrinsic difference in the enzyme itself. This established the role of glycogen as a primer in glycogenesis.

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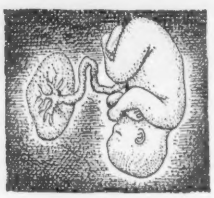

IN NOVEMBER – (1952) – a report from Scandinavia discusses the determination of the nucleic acid content of human placenta. There is good agreement between results obtained by Hammarsten's method and by application of cysteine reactions to the hot T.C.A. extract. Schmidt and Thannhauser values showed considerable divergencies. P.N.A. content decreases sharply with the aging of the placenta, while D.N.A. increases slightly. Thus, there is marked decrease in the P.N.A./D.N.A. ratio during pregnancy.[3]

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1. Mendel, L. B., and Hilditch, W. W.: The influence of alcohol upon nitrogenous metabolism in men and animals. Am. J. Physiol. *27*:1 (Nov.) 1910. 2. Cori, G. T., and Cori, C. F.: Letters to the Editor: The activating effect of glycogen on the enzymatic synthesis of glycogen from glucose-1-phosphate. J. Biol. Chem. *131*:397 (Nov.) 1939. 3. Brody, S.: Quantitative studies on the nucleic acids in human placenta. Acta Chem. Scandinav. *7*:507,1953.

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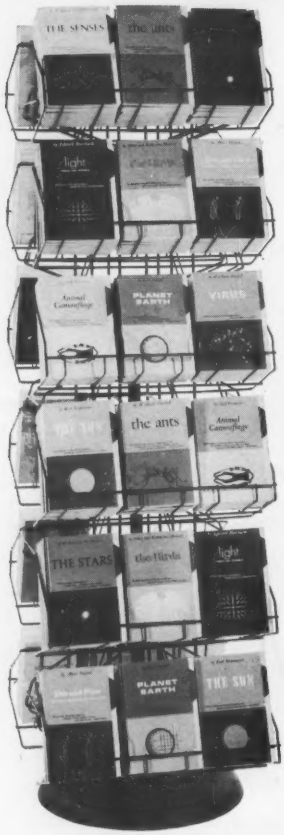

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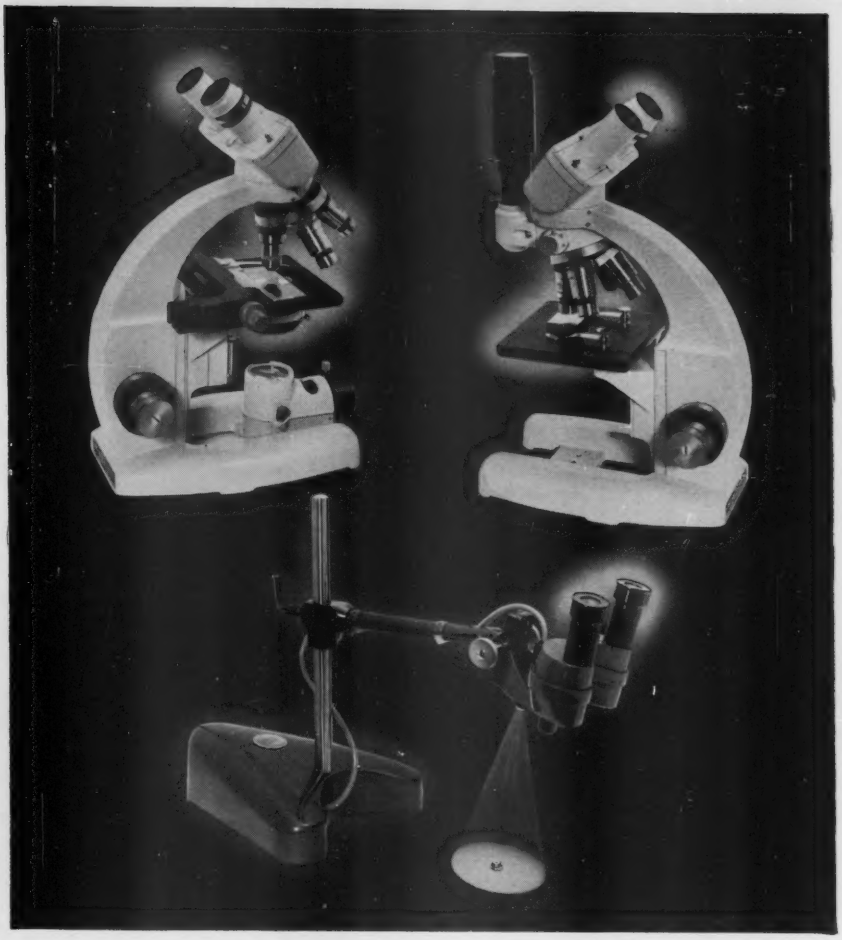

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18 November 1960, Volume 132, Number 3438

SCIENCE

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Science Proves . . .

One need watch television only briefly to learn that scientific instruments, phrases, and symbols are being used—and misused—to promote a wide variety of products. If the listener reacts as the advertiser wishes, he smokes the cigarette chosen by "more scientists and educators" than any other brand, dresses his hair with the preparation that does not evaporate in a solar heater, shaves with the blade that "engineers" call a "scientific breakthrough," and then, for he probably needs it, takes the pill recommended by "three out of four doctors" and follows it with the one shown in blown-up cross section and improved by its "enteric coating."

This din of pseudoscientific chatter has nothing to do with the brilliant generalization or the careful collection of data by which science advances. But for scientists it has two meanings: (i) "science" is a useful sales gimmick, now apparently on a par with endorsement by a pretty girl; and (ii) the public, including children, is given a false and misleading impression of the methods, character, and integrity of scientific work. Against this result there is growing revolt.

What can be done? First, protest. Specific ads that are false or misleading can be protested to the Federal Trade Commission, which invites such reports, and to the advertisers and TV chains, which should receive them whether invited or not.

FTC chairman Earl W. Kintner recently told the Association of Consulting Chemists and Chemical Engineers that scientists and consulting laboratories should extend the scope of their professional responsibility to insist that their findings be properly reported in any commercial usage made of them. Advertisers and advertising agencies, he continued, also have a professional responsibility, and warned them that if they abdicate self-discipline, they invite the imposed discipline of tighter government controls.

Ridicule is also useful. A *New Yorker* cartoon shows an executive blasting as "absolutely unscrupulous" an ad in which SCIENCE, in large caps, is paired with a bottle of unknown content, and adding, "Why didn't we think of it first?"

But attacking misleading ads alone is like treating symptoms; TV ads reflect the state of television as a whole. The widely syndicated critic John Crosby, in a roundhouse swing at the whole industry, recently announced that television has become so bad that it no longer merits a daily column; he will write about it only once in a while. The 1 January 2000 issue of the *Seattle Daily Galaxy* (a publicity paper for the Century 21 International Exposition to be held in Seattle in 1962) discusses tariffs on Mars imports, regrets surplus production of sea farms, and reports low morale at the moon colony. In contrast with these indications of how the world is sweeping on, and in a transparent jibe at the state of television, the day's TV program ends with a movie that was grade B 57 years earlier. Perhaps television executives should be included among the groups that need to develop professional attitudes and self-discipline; TV advertising is not likely to exhibit high standards until TV producers gain respect for the taste and intelligence of their audience.

In the meantime, we can protest and we can ridicule. TV commercials too frequently deserve both.—D.W.

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18 November 1960, Volume 132, Number 3438 SCIENCE

CURRENT PROBLEMS IN RESEARCH

Genetic Systems in Chlamydomonas

Both chromosomal and nonchromosomal systems of genetic determinants are being analyzed in this alga.

Ruth Sager

It is the plan of this article to describe some studies of *Chlamydomonas*, a unicellular alga that is an admirable microorganism for genetical and physiological investigations. Both previously published and current unpublished findings are discussed within the framework of the general working hypothesis. Preliminary results and speculations are included, leaving a more detailed presentation of the data for publication elsewhere (*1*).

The focus of interest in this research has been the investigation of nonchromosomal heredity. Attention has been centered principally upon two systems: chloroplast formation, known from studies with higher plants (*2*) to be influenced by nonchromosomal as well as by chromosomal genes, and streptomycin resistance. My co-workers and I have studied chromosomal heredity in *Chlamydomonas*. In addition, we have studied a nonchromosomal genetic system exhibiting uniparental transmission and conferring streptomycin resistance, and we have preliminary evidence about a different genetic system involving the chloroplast.

Before discussing these systems, let us take a quick look at the organism itself (*3*). Normal green cells each contain one cup-shaped chloroplast which occupies about 50 percent of the cell volume and contains all of the chlorophyll, carotenoids, and the enzymes of photosynthesis and of the CO_2-to-starch pathway. The schematic diagram in Fig. 1 summarizes the principal structural elements of the organism as seen in light and electron microscopy. Electron micrographs of thin sections of normal green and dark-grown yellow mutant cells show the similarities and differences in chloroplast structure which have resulted from the absence of chlorophyll in the yellow mutant, y_1^-. Although the total chloroplast volume remains unchanged, and starch is stored as usual, no organized lamellar membranes form in the absence of chlorophyll. When such yellow cells are placed in the light, chlorophyll synthesis begins at once, and within 24 hours they are indistinguishable from normal green cells. Thus, the ability to make a normal chloroplast has not been irreversibly lost in this yellow mutant. I return to this point below in discussing the inheritance of the y_1 factor.

The simple life cycle of *Chlamydomonas* (Fig. 2) involves fusion of haploid cells of opposite mating type to form the diploid zygote, which does not divide mitotically but undergoes meiotic reduction with the production of four haploid progeny. Tetrad analysis, the genetic analysis of all four products of individual meioses, can be readily carried out with this material. Gilbert Smith first obtained the complete life cycle of *Chlamydomonas reinhardi* on defined media, and Smith and Regnery showed that mating type was inherited as a unit factor difference (*4*). Subsequently, the mating type gene was located about 35 map units from its centromere, and a number of other genes were mapped (*5*). Through tetrad analysis it was shown that regular 1:1 segregation of alleles was the rule, and no abnormalities were apparent in the segregation of a number of genes affecting drug resistance and pigment formation (*5*). Similar regularities have been reported in the segregation of nutritional mutants (*6*). In the results discussed here, tetrad analysis was employed and centromere distances were computed as in previous publications (*5*, *7*).

A Genetic System Involving Uniparental Transmission

When wild-type *Chlamydomonas* is plated on streptomycin-agar (100 micrograms per milliliter), most cells die, and the colonies which appear consist of streptomycin-resistant (*sr*) mutants. Under standardized conditions, two classes of *sr* mutants are found: *sr*-100, resistant to 100 μg of streptomycin per milliliter on agar, and arising with a frequency of about 10^{-6}, and *sr*-500 (previously called *sr*-2), resistant to 500 μg/ml and arising with a frequency of about 10^{-7} under conditions discussed below. Fifty-seven *sr*-100 mutants of independent origin have been crossed to wild type: all segregate 1:1, and the *sr*-100 factor in one of the strains has been located by tetrad analysis about 20 map units from its centromere.

With the *sr*-500 mutants, streptomycin resistance segregates in an entirely different manner at meiosis. Twenty-seven independently isolated *sr*-500 strains, phenotypically indistinguishable in resistance level, and derived from both mating types, have

The author is research associate on the staff of the department of zoology of Columbia University, New York, N.Y. This article is based on the first Gilbert Morgan Smith memorial lecture, given at Stanford University, Stanford, Calif., on 1 February 1960.

been crossed. All of them show the same pattern of inheritance of resistance as the *sr*-2 strain initially described (*7*). As shown in Fig. 3, the *sr* determinant in this strain exhibits only uniparental transmission, all progeny corresponding to the resistance level of the parent of mating type *plus*. The demonstration that this pattern of segregation does not result from multifactorial inheritance, from chromosome aberration, or from a lag in expression of the progeny phenotypes has been previously reported and discussed (*7*).

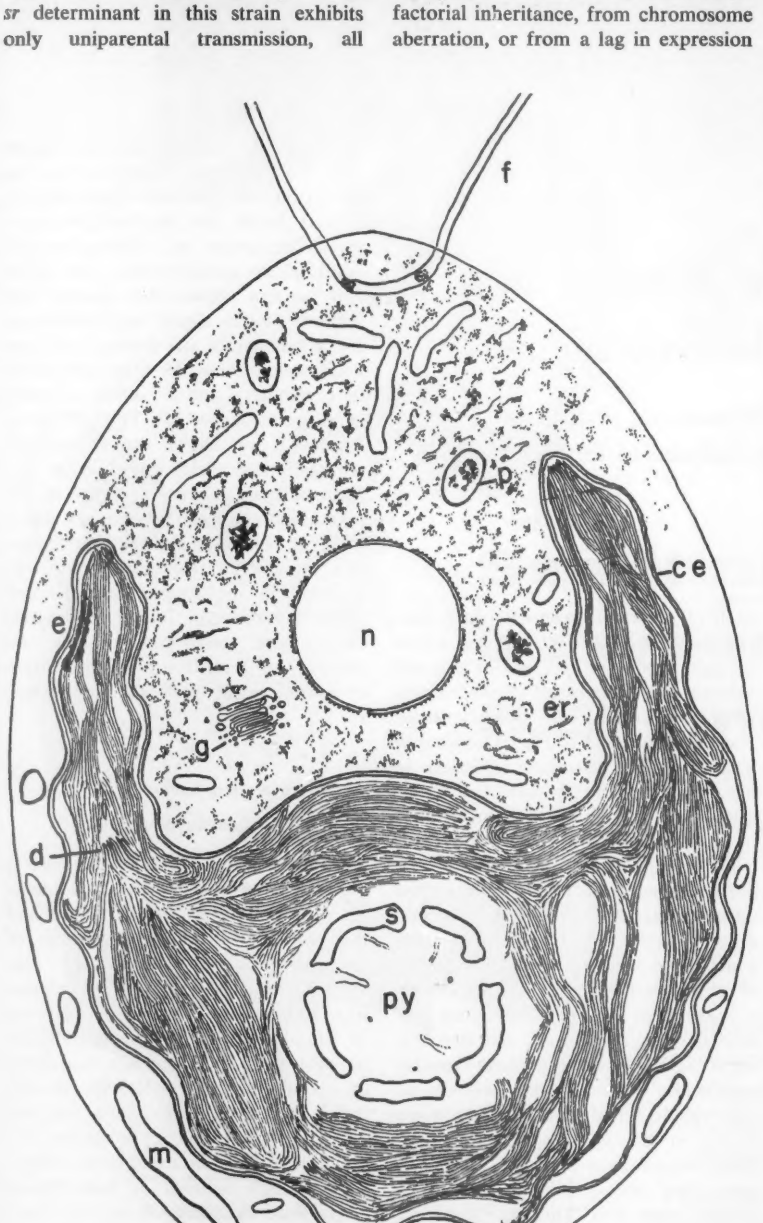

Fig. 1. Diagrammatic sketch of normal green *Chlamydomonas* as seen at low magnification in the electron microscope. The chloroplast is shown surrounded by the double chloroplast envelope (*ce*) within which the eye-spot (*e*), pyrenoid (*py*), and starch plates (*s*) are located, as well as the paired lamellar membranes arranged as discs. At low magnification the disc arrangement is clearly seen only in occasional well-oriented regions. The cytoplasm also contains other systems of organelles, including mitochondria (*m*), Golgi material (*g*), endoplasmic reticulum (*er*) consisting of membranes and ribonucleic acid-containing granules, and vacuoles containing metaphosphate (*p*). The nucleus (*n*) is surrounded by a double membrane with pores and a dense coating of ribonucleic acid-containing granules on its outer surface.

The *sr*-500 determinant is noteworthy for its stability. No reversions to sensitivity have been found over a period of several years, or after a variety of treatments designed to inactivate it or to dilute it out. All of our evidence to date indicates that the *sr*-500 factor is at least as stable and as well integrated in the cell as are chromosomal genes. Electron micrographs of *sr*-500 cells likewise have revealed no differences from the morphology of wild-type sensitive cells.

Two other phenotypic traits, one being streptomycin dependence (*sd*) and the other being resistance to 1500 μg of streptomycin per milliliter (*sr*-1500), have been found to exhibit the same pattern of uniparental transmission as does resistance to 500 μg/ml (*8*). Only one streptomycin-dependent strain has been recovered in many searches for mutants. It grows best with 100 μg/ml but survives well with 500 μg/ml. In the absence of streptomycin, vegetative cells multiply slowly for a few divisions and then stop growing, but do not die. The new clones arising after a cross, however, have an absolute streptomycin requirement and die very quickly if it is not met. The pattern of inheritance of *sd* is shown in Fig. 4; all progeny resemble the parent of mating type *plus*. It would be interesting to obtain a double *sd sr*-500 mutant, but as yet this has not been accomplished because of the uniparental pattern of transmission. As previously reported (*7*), occasional zygotes transmit *sr*-500 from the parent of mating type *minus*, and experiments are in progress to screen for such exceptions in crosses with *sd*.

A number of *sr*-1500 strains were isolated after subculturing an *sr*-500 mating type *minus* strain on streptomycin. They may be either double mutants (*sr*-500 plus *sr-x*) or mutated *sr*-500's. Whichever is the case, the resistance is lost in crosses to wild-type cells (*ss*) of mating type *plus*. Some of these strains subsequently were found to be unstable, reverting back to the 500-μg/ml level of resistance.

Recently a chromosomal gene, *A*, has been found which amplifies the resistance level both of the chromosomal *sr*-100 and of the nonchromosomal *sr*-500, although it confers no resistance itself upon *ss* strains (*8*). Thus, strains of *ss A* and *ss a* are phenotypically indistinguishable, but

strains of *sr*-100 *A* and *sr*-500 *A* are each resistant to over 2 mg/ml (Table 1). The presence of *A* does not alter the pattern of inheritance of *sr*-500, as shown in Fig. 5, despite the evident physiological interaction between the two determinants. *A* resembles *sr*-100 (with which it is unlinked) in not influencing the inheritance pattern of *sr*-500, and in segregating independently from it. It has also been found that neither *A* nor *sr*-100 influence the segregation of *sd*.

We have employed a number of these genotypic combinations in preliminary studies of the physiology of streptomycin resistance. Using streptomycin-C^{14} (*9*) we examined the uptake of the drug by the following strains: *ss a*, *ss A*, *sr*-100 *a*, *sr*-100 *A*, *sr*-500 *a*, and *sr*-500 *A* (*10*). On exposure to 50 μg/ml, they all bind streptomycin to the same extent, about 10^8 molecules per cell, as determined by radioactivity counts of water-washed cells. This binding remains constant for more than 24 hours. If cells are washed with growth medium before counting, most of the radioactivity comes out, leaving a residue of 5 to 10 percent which increases slowly with continued exposure to the drug. These experiments provide no evidence of permeability differences between the strains, in contrast to observations reported with *Escherichia coli* (*11*). Further studies of the kinetics of uptake are in progress.

In our system, a more sensitive indicator of streptomycin uptake is its effect upon chlorophyll synthesis. Sublethal concentrations of the drug interfere with the synthesis of chlorophyll in the dark, a step which can be performed by wild-type *Chlamydomonas*. The sensitive step is blocked reversibly by streptomycin in *ss* and *sr*-100 strains, but not in strains containing *sr*-500 or *sd* (Table 1). Apparently, the site at which streptomycin blocks chlorophyll synthesis is more available in cells with *sr*-100 than in cells containing *sr*-500. The presence of *A* does not alter the picture. These results indicate that a difference exists in the mode of action of *sr*-100 and *sr*-500, despite the ability of each to interact with *A*.

Thus we have four nonchromosomal determinants, or one determinant with four alternative forms (*ss*, *sr*-500, *sr*-1500, *sd*), which all exhibit the same pattern of inheritance. In our view, these determinants are permanent cell constituents, ranking with chromosomal genes as part of the hereditary repertory

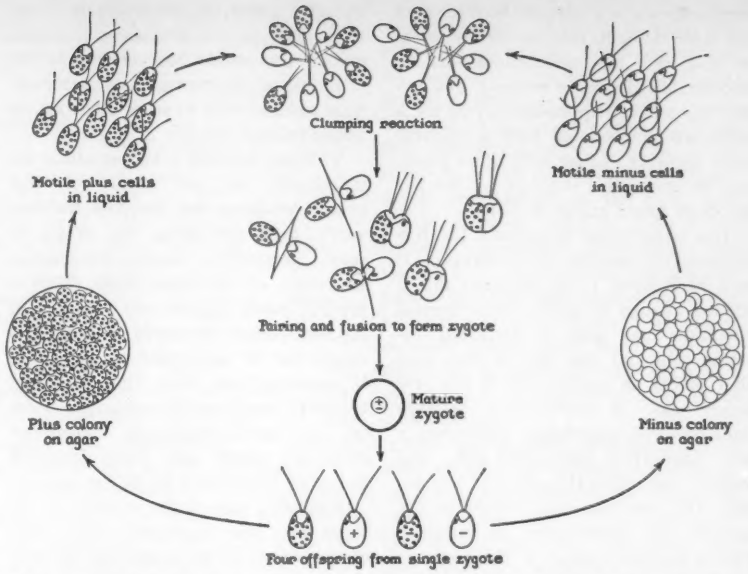

Fig. 2. The life cycle of *Chlamydomonas reinhardi*, showing the segregation of mating type, denoted by plus and minus signs, and of the marker y_1 (the dotted cells are y_1^+, the undotted are y_1^-).

of the organism. They are well integrated both in physiological and in replication mechanisms, and their pattern of inheritance is independent of their state of expression.

What Are Nonchromosomal Determinants?

Stable hereditary determinants exhibiting nonchromosomal patterns of segregation in meiosis have been reported since the early days of Mendelian genetics, but in no instance has either their chemical constitution or their location within the cell been established. Despite this paucity of information, there has been no dearth of hypotheses about them. Before turning to further experimental evidence, it might be useful, for purposes of orientation, to consider briefly what some of these hypotheses have been.

On the gene hypothesis, these determinants are permanent cell constituents which replicate and segregate in a regular manner, well integrated with cell division. They are genes without chromosomes. Their stability does not depend upon whether they are latent or expressed; their nonappearance as spontaneous or radiation-induced mutants may result from their presence in the cell as a number of replicates. If so, their mutation or loss might require some sort of directed, not random, event. This consideration led us to study the conditions under which *sr*-500 mutants arise, as discussed below.

The episome hypothesis of Jacob and Wollman (*12*) is an extrapolation from the finding in *Escherichia coli* of two kinds of genetic particles (prophage and *F*) which can exist either localized on a chromosome and well integrated in the cell or not localized on a chromosome, poorly integrated, and infectious. If the ability of genetic elements to attach to and detach from

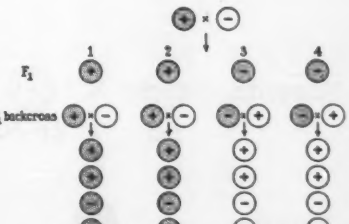

Fig. 3. Inheritance of streptomycin resistance of strain *sr*-2. Plus and minus signs refer to mating type. The initial cross, *sr* $mt^+ \times$ *ss* mt^-, gave rise exclusively to *sr* offspring, which segregated 2:2 for the markers *mt* and y_1. F_1 clones of plus mating type backcrossed to *ss* mt^- produced all *sr* offspring (4:0), but F_1's of minus mating type backcrossed to *ss* mt^+ produced only sensitive progeny (0:4). Stippled, streptomycin-resistant; unstippled, streptomycin-sensitive.

chromosomes is a general feature, then the same elements may be chromosomal at one time and nonchromosomal at another. Evidence to support this hypothesis would require identifying for a particular determinant both a mapable state, showing linkage with other genes, and an unmapable state; as yet this has not been found except in *E. coli*.

The steady-state hypothesis [as formulated, for example, by Delbruck (*13*) and by Pollock (*14*)] proposes that a sudden change in some environmental condition may alter a particular reaction rate and that this in turn may alter others, in such a way that a new steady state of interlocking reaction rates becomes established, conferring a new phenotype upon the cell, and thereby mimicking the effect of a mutation. The new phenotype would be expressed and transmitted to progeny, until a suitable change in the environment intervened. One cannot predict the stability of such systems a priori, but it seems unlikely that they would persist for years in the absence of the inducing agent, as streptomycin resistance does in the absence of streptomycin. Catcheside has referred to the "conditional permanence of a steady-state system" (*15*) to set it off from the unconditional stability of a gene.

Virtually nothing is known about the inheritance of cell structures, but cytologists have, for the past hundred years, been describing the origin of some organelles from pre-existing structures of the same kind. Such a process would require the presence of supertemplates concerned with the arrangement of aggregates of molecules. If supertemplates exist, they represent a class of hereditary determinants. Some of the nonchromosomal chloroplast mutations which have been described in higher plants may be of this type.

Returning now to the *sr* mutants, we favor the first hypothesis—that nonchromosomal determinants are genes—as being closest to the experimental observations so far available, for the following reasons: (i) The absence of segregation in crosses and the uniparental transmission through the zygote show that the determinant is not on a chromosome during meiosis. It seems very unlikely that it leaves the chromosome during meiosis, when segregation is so critical, and becomes reintegrated with the chromosome at other times, but this possibility has not been excluded. (ii) The identification of four different phenotypes with respect to streptomycin, all showing the same pattern of uniparental heredity, suggests that they may represent mutational alternatives (or different alleles) of the same determinant. (iii) The unconditional stability of the *sr*-500 factor under a great variety of environmental conditions and growth rates, and after five generations of outcrossing, all in the absence of streptomycin, argues against the application of the steady-state hypothesis to this system. (iv) The fact that *sr*-500 interacts with the chromosomal gene *A* in conferring a higher resistance level upon the cell, without altering the *sr*-500 pattern of inheritance, is further evidence of the separation of physiological expression from hereditary transmission. Such a separation is one of the principal features of genetic material, in contrast to steady-state systems. (v) Evidence of the nonchromosomal nature of the material comes also from studies of its mutational origin, discussed below.

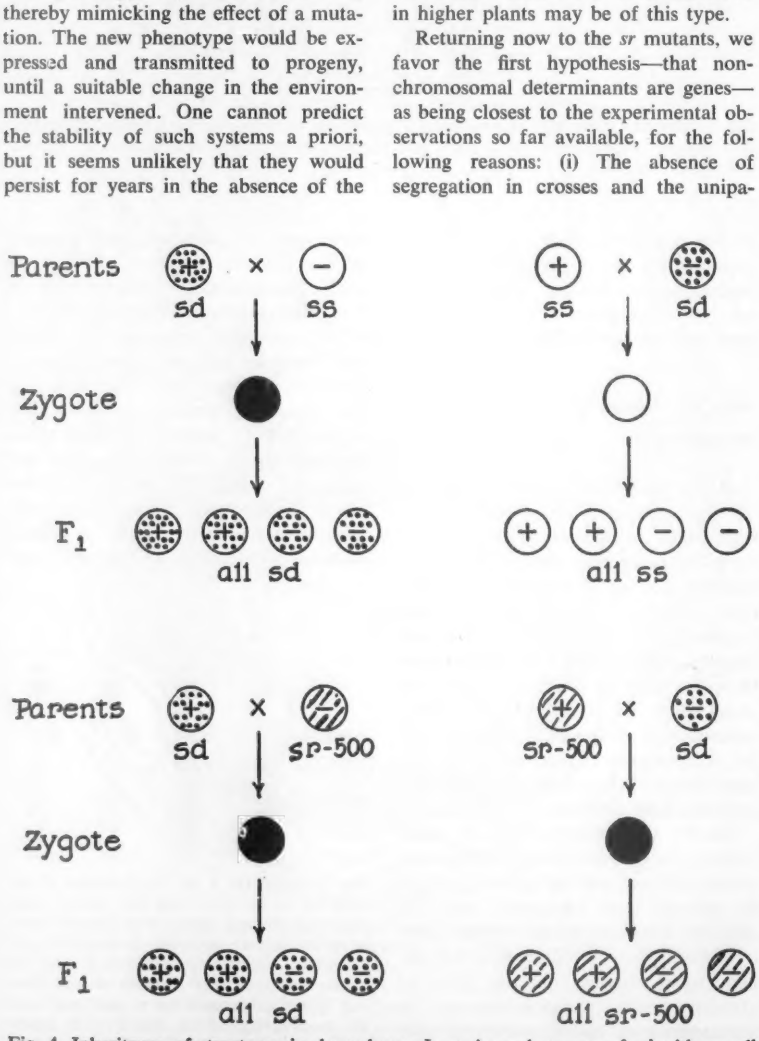

Fig. 4. Inheritance of streptomycin dependence. In reciprocal crosses of *sd* with *ss*, all progeny resemble the parent of mating type *plus* in their response to streptomycin. The same is true in reciprocal crosses of *sd* with *sr*-500. Dotted, *sd*; hatched, *sr*-500; white, *ss*; black, not *ss* but may be either *sd* or *sr*-500.

Streptomycin as a Mutagen of Nonchromosomal Elements

A long-term investigation has been in progress to analyze the conditions required for mutation from *ss* to *sr*-500 (*10*). Initially, the plan was simply to find out whether or not *sr*-500 mutants appeared at random in populations of *ss* cells before treatment with streptomycin. Technical difficulties in the system arose from the very low frequency of *sr*-500 mutants recovered and from the lethality of streptomycin; both of these properties complicate the analysis. As a result, it has not been possible to obtain a fully unequivocal answer, but a number of lines of evidence support the view that mutations to *sr*-500 occur only in the presence of streptomycin.

1) The frequency of *sr*-500 mutants appearing on streptomycin-agar plates is a function of the survival time of *ss* cells on the plates. This time can be varied within wide limits by varying the medium used. In general, no *sr*-500 mutants are recovered on minimal

medium under conditions in which *ss* cells die rapidly in contact with the drug. Addition of acetate to the medium (at the same *p*H), which greatly increases survival time but allows only one or two doublings of cells, results in the appearance of *sr*-500 mutants, in yields at least 100 times that of controls without acetate. The increase in number of mutations is not proportional to the increase in population size but is a function of survival time in the presence of streptomycin.

2) Even with a favorable medium, *sr*-500 mutants are found only at a low streptomycin concentration (100 μg/ml), although immediately after recovery, these mutants are fully resistant to 500 μg/ml. Once established, *sr*-500 mutants show no lag in growth with a concentration of 500 μg/ml, even after years of subculture in the absence of the drug. Thus, it seems that the *sr*-500 mutants develop resistance gradually, in contrast to the behavior of chromosomal mutants, but that, once established, the resistance level is maintained.

3) In fluctuation analysis, no accumulation of pre-existing *sr*-500 mutants has been found; in these experiments *sr*-500 mutants arise only as plate mutants, despite the screening of large populations of cells. On the other hand, mutations to the chromosomal *sr*-100 occur in the tubes with the expected high variance of spontaneous mutations, and at a rate consistent with the frequencies observed in other experiments.

These experiments clearly demonstrate the difference in mutational response of the genetic elements *sr*-100 and *sr*-500, and the results are consistent with the hypothesis that *sr*-500 mutations are induced by streptomycin. (Possible mechanisms of this induction include the intracellular selection of particles which may have mutated independently.) The alternative possibility, that there is a special requirement for *expression* of spontaneous *sr*-500 mutations, rather than for the mutation process itself, has not been fully excluded.

Support for the induction hypothesis has come from another line of work: the mutagenic effect of streptomycin upon chlorophyll-forming ability. It may be recalled that some years ago streptomycin was reported to inhibit the greening process in young seedlings of higher plants (*16*) and in the green flagellate *Euglena* (*17*). In both systems, under some conditions, the loss of greening ability was permanent. These results are very interesting, for they suggest that streptomycin has induced a mutation in a genetic determinant.

Table 1. Phenotypic properties of various streptomycin-resistant and streptomycin-dependent strains. *S*, streptomycin.

Genotype	Streptomycin-resistance level on agar (μg/ml)	Chlorophyll-forming ability in dark	
		Without S	With S
y_1^+ *ss a*	20	Green	Yellow
y_1^+ *ss A*	20	Green	Yellow
y_1^+ *sr*-100 *a*	100	Green	Yellow
y_1^+ *sr*-100 *A*	2000	Green	Yellow
y_1^+ *sr*-500 *a*	500	Green	Green
y_1^+ *sr*-500 *A*	2000	Green	Green
y_1^+ *sd a*	500	Green	Green
y_1^+ *sd A*	2000	Green	Green

In *Chlamydomonas* we have found that streptomycin interferes specifically with formation of chlorophyll in the dark (*18*). When wild-type cells, which are killed by 20 μg of streptomycin per milliliter, are treated with sublethal concentrations of the drug, the synthesis of chlorophyll in the dark is blocked, but the effect is reversible. No permanent effects of streptomycin have been observed at these low concentrations. With the use of streptomycin-resistant strains, it has been possible to obtain yellow mutants in which the ability to form chlorophyll in the dark has been permanently lost. To achieve this result, cells must be grown with a high concentration of streptomycin for some time. Experiments have been carried out on agar, rather than in liquid, to make sure that all cells of the initial population are being observed, not just a selected group of pre-existing mutants.

In preliminary experiments we found that cells containing the *sr*-500 factor could be grown on 1500 μg of streptomycin per milliliter in the dark, with about 50 percent viability. Most of the colonies developing under these conditions gave rise to some permanently yellow progeny upon subculture in the absence of streptomycin. However, colonies formed very slowly, and the possibility of selection occurring within clones led us to experiment with lower concentrations.

Cells grown with 1000 μg/ml in the dark showed 100 percent viability, although on streptomycin they were pale green in color. Since streptomycin does not destroy existing chlorophyll but only interferes with new synthesis, it was necessary to subculture treated cells to determine the effects of the drug. In these experiments, both streptomycin-treated and control colonies were subcultured with and without streptomycin, and marked differences were observed. The results are summarized very briefly here.

Essentially we found that one treatment of cells by growth in the dark with streptomycin had induced a reversible susceptibility of the chlorophyll-forming system to a second treatment of the same kind. Thus, if cells from the first streptomycin-agar plates

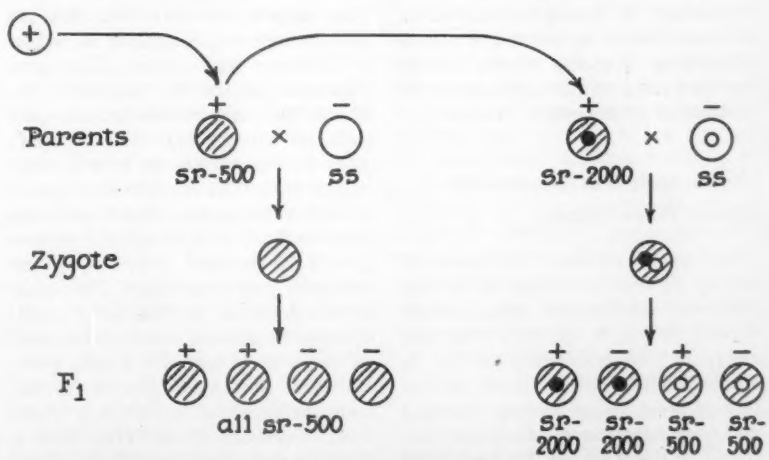

Fig. 5. Inheritance of resistance to 2000 μg of streptomycin per milliliter. Strains of mating type *plus*, carrying *sr*-500, segregate 4:0 for streptomycin resistance in crosses with *ss*; strains carrying both *sr*-500 and the chromosomal gene *A* crossed with *ss a* segregate 2:2 for resistance to 500 μg/ml and 2000 mg/ml. Thus the 2:2 segregation of *A*/*a* is superimposed on the 4:0 segregation of *sr*-500. Hatched, *sr*-500; white, *ss*; black nucleus, *A*; white nucleus, *a*.

were subcultured in the absence of streptomycin, they produced as many green progeny as did the controls, but the same clones subcultured with streptomycin gave rise to a high percent of yellow colonies, which were subsequently yellow in the absence of streptomycin. Approximately 22 percent of yellow colonies were obtained, in contrast with 0.1 percent in the controls given one treatment with streptomycin and about 0.01 percent in the completely untreated initial controls. The observed frequency of yellow colonies represents an underestimate of the number of mutations which occurred, because some of the induced yellow strains were unstable and were characterized by a constant tendency to revert from yellow to green, this mutability itself being a heritable property transmitted by the yellow cells in mitosis and also in meiosis (*18*).

At least half of the yellow colonies obtained—that is, clones representing about 10 percent of all initially treated cells—remained stable yellow upon further subculture and in crosses with other strains. This number itself represents a 1000-fold increase over the controls. That these strains result from induced mutation, not from selection, is shown by the viability of both green and yellow cells under the conditions of the experiment.

We have not yet investigated the mutagenicity of streptomycin towards other cell traits, because it seems important first to define the cellular changes which correlate with the induced effects already observed. If the mechanism of mutagenic action of streptomycin can be clarified at all, the information acquired thereby should provide a less empirical approach to the recovery of other kinds of mutants.

Genetic Analysis of Streptomycin-Induced Yellow Mutants

In previous studies of mutations affecting pigment formation (*5*) it was seen that spontaneous mutations involving the loss of chlorophyll-forming ability in the dark segregated 1:1 in crosses with wild-type green strains. One of these yellow mutants provided the y_1^- genetic factor subsequently included in many crosses. By now, more than 800 tetrads have been analyzed in which a number of genetic pairs, including y_1^-/y_1^+, were segregating. In all of these crosses, the y_1 pair showed only first-division segregation.

This datum can be interpreted either as complete linkage with a centromere or as evidence of a nonchromosomal location. In the absence of any crossing over with the centromere, the demonstration of recombination with some known chromosomal factor is necessary to establish a chromosomal location for y_1. To date we have eliminated five chromosomes, of the eight to ten occurring in this species, as carriers of y_1, and we are in the midst of testing the others. Since this organism has but one chloroplast per cell, the 1:1 segregation might conceivably be that of a unit cytoplasmic organelle segregating in an oriented manner at the first meiotic division, rather than that of a chromosome.

Although the hypothesis that y_1 is nonchromosomal has been under consideration for some time, we have not had markers on all the chromosomes to provide a critical test. Our recent findings concerning the streptomycin-induced yellow mutants have provided new support for this hypothesis from a different point of view. Ten independently arising streptomycin-induced yellow mutants have been crossed with our standard spontaneous y_1^-, and no green recombinants were recovered, with thousands of zygotes scored in each cross. Evidently, then, the spontaneous and the induced yellow mutants result from mutation of the same determinant, and the linkage analysis carried out with the original y_1^- applies as well to the new y_1^- factors.

Without representing critical evidence, the inducibility of the y_1 mutations supports the view that they are nonchromosomal, because of the weight of evidence that chromosomal gene mutations cannot be specifically induced. The action of chemical mutagens such as nitrous acid, 2-aminopurine, and 5-bromo-uracil seems to be directed against individual nucleotides or short sequences rather than against the large functional unit as a whole, and the frequency of induced mutation of any particular gene is very low. The action of streptomycin, on the other hand, seems to be directed specifically against y_1, in the sense that such a great number of the treated cells give rise to mutants. Perhaps the y_1 factor is much more accessible to the drug than a chromosomal gene would be. This speculation is supported by the evidence that *sr*-500 determinants, which are clearly nonchromosomal, are also induced by streptomycin. In our view, the working hypothesis that streptomycin is a mutagen of nonchromosomal genes seems to accord best with the evidence so far available.

Conclusion

In this article I have discussed two genetic systems which appear, for different reasons, to be nonchromosomal. In neither system is the evidence complete, for the determinants themselves have not been identified. It is already clear, however, from their patterns of inheritance, that the two systems are different, for the chloroplast system is independent of mating type in its transmission, while the streptomycin-resistance system is transmitted only by one mating type. From the cytologist's viewpoint (Fig. 1), there are many organelles and membrane systems with a precision and complexity of organization suggesting genetic control. It is likely that different organelles are duplicated and transmitted through the zygote in contrasting ways. If so, our *sr* and y_1 determinants may actually represent markers, reflecting these differences in the mode of inheritance of different cytoplasmic structures.

In the past, it has been a great convenience for geneticists to think exclusively in terms of a single genetic system carried on chromosomes, particularly since chromosomal genes have provided the determinants most accessible to random change. In the modern analysis of cell heredity and gene action, however, it is of the utmost importance to identify all classes of genetic determinants. In attempting to carry out such a program with *Chlamydomonas*, streptomycin has provided a means for the recovery of two classes of genetic factors which differ in a number of properties from chromosomal genes. It is our hope that further analysis of these two systems will lead to their specific identification, and beyond that, to a more informed approach to the search for further genetic systems (*19*).

References and Notes

1. In some aspects of this work I have enjoyed the collaboration of Dr. Yoshihiro Tsubo and the assistance, at various times, of Sydell Fleischer, Charlotte Marfey, Ann Shiffer, Christine Thomas, and Fran Yablonsky. It has been my good fortune to collaborate with Dr. George E. Palade in the electron microscopy. The generosity and interest of Prof. Francis J. Ryan in providing laboratory space for this work and his assistance in other ways is gratefully acknowledged.
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Radiation Environment in Space

Satellites and space probes are revealing the kinds and amounts of radiation men will encounter in space.

Homer E. Newell and John E. Naugle

That vast region beyond the earth's atmosphere often referred to as the void of outer space is not really empty. Through interplanetary space there stream electromagnetic radiations of all wavelengths, electrons, protons, and other nuclei, including cosmic rays, and aggregate particles called micrometeorites. In fact, many of the fundamental particles and quantum radiations have already been observed, and, doubtless, all will be eventually.

Within the solar system, the sun is the primary source of both electromagnetic radiations and particle radiations. In addition to the visible wavelengths which pour forth continuously from the sun, there are ultraviolet and x-ray radiations of variable intensity. At times of great solar activity clouds of electrons and protons are spewed forth and sweep through the regions of interplanetary space. It even appears likely that the sun may contribute to the cosmic radiation.

Before May 1958, radiation was not considered a serious hazard to space travel. Little was feared from the electromagnetic radiations to be encountered. Most of the wavelengths would be in the visible regions, and it was expected that the ultraviolet and x-ray intensities would be low enough to cause no concern. Rocket observations bore out this conclusion. Moreover, the available experimental data indicated that the only particle radiations in space would be cosmic rays, and that the radiation level due to cosmic rays would be negligible for most space missions.

However, on 1 May 1958, James A. Van Allen announced the discovery of the great radiation belts around the earth. The radiation levels in these belts are not negligible. A second phenomenon, the so-called solar proton beams, or solar cosmic rays, was discovered shortly thereafter. Thus, in the course of a few months radiation changed from an unimportant factor in space travel to a major factor affecting the choice of trajectories and determining the size and weight of the spacecraft and their physical configuration.

In this article we summarize some of the information on radiations in space obtained by means of satellites and space probes. The physical nature of these radiations is discussed, together with the mechanism by which the radiation interacts with matter. Dosage levels are defined. The salient factors in the choice of shielding are given. Finally, an attempt is made to assess the importance of radiations in space to various space missions, such as Project Mercury, circumlunar flights, and the operation of unmanned satellites and space probes.

Electromagnetic Radiations

As stated above, the electromagnetic radiations encountered in interplanetary space are primarily solar in origin. At a distance of one astronomical unit from the sun, the total energy flux in this solar radiation amounts to about 2 calories per square centimeter per minute, which is equivalent to 0.14 watt per square centimeter. The radiation is mostly in the visible wavelengths. About 7 percent of the total energy flux lies in the ultraviolet regions between 2000 and 4000 angstroms; in still shorter wavelengths in the vicinity of the Lyman-alpha line of hydrogen, 1216 A, the total intensity is down by many orders of magnitude, averaging about 6×10^{-7} watt/cm^2. In the soft x-ray wavelengths intensities fall off another order of magnitude or more. Occasionally harder x-rays are observed at the time of the solar flares. Gamma radiation is normally of negligibly small intensity.

Rocket observations by the Naval Research Laboratory group have revealed ultraviolet fluxes from distant astronomical sources. Moreover, the hydrogen in interstellar and interplanetary space is a source of some radiation in the Lymap-alpha wavelengths.

The intensity of the solar radiations

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will vary inversely as the square of the distance from the sun. Thus, at the distance of Venus from the sun the total solar energy flux may be expected to be about twice that at the earth's distance, or 0.28 watt/cm². At the distance of Mars this figure would become 0.06 watt/cm².

In the vicinity of a planet, a satellite or spacecraft would also be subject to radiation from the planet itself. Much of this radiation will be in the infrared. In the case of the earth, this amounts to about 0.06 watt/cm² on the average. In addition, the planet reflects incoming solar radiation in amounts determined by the planetary albedo, which for the earth is 0.4. Within the shadow cast by the planet, the solar radiation is, of course, cut off.

In general, it does not appear that electromagnetic radiations within the solar system present a serious hazard to space flight, until close approaches to the sun are made. It is possible with very little effort to provide shielding from the different radiations. It is a matter of straightforward engineering to provide adequate cooling for equipment and living occupants of satellite stations or spacecraft. Under the action of the shorter wavelengths, certain materials, such as plastics, may be expected to undergo long-term changes in properties. If such changes have an adverse effect for the use to which such materials are being put, then either protection must be provided or substitute materials must be found. But none of these problems should furnish any deterrent at all to space operations and space flight.

Cosmic Rays

The cosmic radiation contains the most energetic particles known. Energies of individual particles range from a few million to 10^{19} electron volts. The primary radiation found in interplanetary space consists of protons, alpha particles, and the nuclei of heavier elements up to at least iron. The protons comprise roughly 86 percent of the radiation, 13 percent is accounted for by the alpha particles, and the remaining 1 percent consists of the heavier particles. Away from the earth in interplanetary space, the total intensity is about two particles per square centimeter per second from all directions. In the vicinity of the earth, this intensity is divided by two, due to the shielding effect of the earth itself.

Near a planet containing an atmosphere one may expect an additional component to the cosmic radiation caused by back scatter of secondary particles, due to collisions of the primaries with the atmospheric molecules. For the earth this albedo, as it is often called, has been observed and measured. This albedo consists of neutrons, mesons, and various decay products of these particles. The intensity is sufficiently great to suggest that the cosmic ray albedo is the source of some of the radiation trapped in the Van Allen radiation belt, particularly in the inner zone.

As measured at the earth, the cosmic ray flux varies by a factor of two during the 11-year solar cycle, with the maximum cosmic ray flux occurring at the time of minimum solar activity.

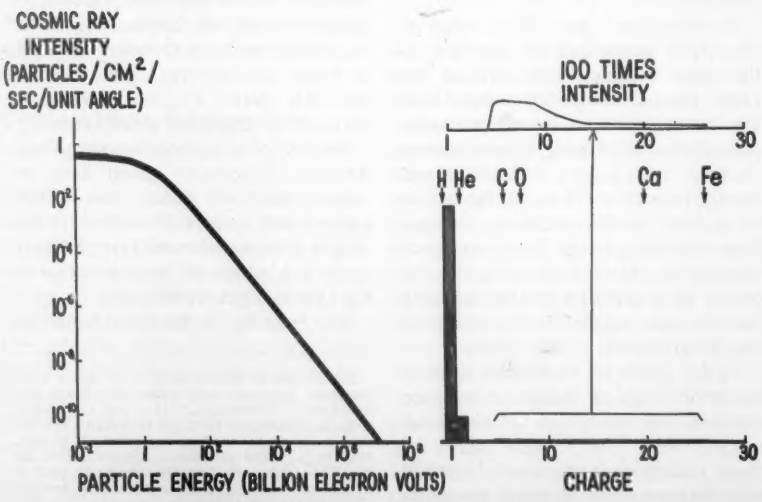

Fig. 1. Cosmic ray energy and charge spectrum.

Table 1 gives the fluxes of the particles in the cosmic radiation and their relative abundance. These figures are obtained by extrapolating fluxes measured at balloon altitudes to the top of the atmosphere. The value for the total flux is that measured in satellites and deep space probes.

Figure 1 shows the variation of the cosmic ray flux with energy. Figure 2 shows the manner in which cosmic rays interact with the nuclei of the atmosphere to produce secondaries. Figure 3 shows the effect of the earth's magnetic field on a very low energy, a medium-energy, and a high-energy cosmic ray.

Trapped Radiation

The first Explorer satellite led to the discovery by Van Allen and his colleagues of the belt of high-energy particle radiations surrounding the earth. Since its discovery the radiation belt has been investigated in the United States with the Explorer satellites and Pioneer probes, and in the U.S.S.R. with the Sputniks and Soviet space probes.

It has become clear that the earth's radiation belt consists of charged particles trapped by the earth's magnetic field, as shown in Fig. 4. The particles travel in spiral paths along the magnetic line of force from pole to pole. As a particle moves toward a pole the pitch angle between the particle's path and the direction of the magnetic field becomes greater and greater, until finally it reaches 90°. At this point the particle is reflected and begins to spiral back along the same line of force. Thus the particle travels back and forth until collisions with atmospheric molecules or other effects remove it from the radiation belt.

It seems clear that any planet possessing a magnetic field of sufficient strength will also exhibit a radiation belt similar to that of the earth. Thus the problems in space flight introduced by the earth's radiation belt may be expected to be encountered again in the case of flights in the vicinity of other planets.

As shown in Fig. 4, the earth's radiation belt appears to consist of at least two separate regions. Both zones contain appreciable numbers of electrons ranging in energy from 20,000 electron volts to several times 10^5 ev or more. In the outer zone, the electron flux is a couple of orders of magnitude greater than in the inner re-

Table 1. Flux and relative abundances of particles in cosmic radiation. Fluxes are measured in balloons and extrapolated to the top of the atmosphere. Interplanetary flux is that measured on Pioneer IV.

Type of particle	Flux (particle cm^{-2} sec^{-1} $ster^{-1}$)	Relative abundance (%)
Electrons ($E \geqq 30$ Mev) (6)	—	<1
Protons ($E \geqq 280$ Mev) (7)	0.095	86
Alphas ($E \geqq 160$ Mev/nucleon)	.015	13
$3 \leqq Z$ ($E \geqq 360$ Mev/nucleon) (8)	.0014	1
Total from balloons	.111	100
Interplanetary flux	.14	100
(Protons, $E \geqq 30$ Mev) (Electrons, $E \geqq 2$ Mev)		

gion. The inner region, on the other hand, is characterized by the presence of high-energy protons, which are not detected in the outer region.

Because the dipole field of the earth is offset from the center of the earth by 360 kilometers, there is a longitudinal variation in the lower edge of the radiation belt. The altitude of the lower edge of the inner belt is as low as 460 km over Santiago, Chile, and as high as 1480 km over Australia.

The particles trapped in the radiation belt are found in appreciable quantities at altitudes above 1000 km over the equator, and above 300 km in northern latitudes. Over the equator, the maximum intensity of the inner zone appears at somewhat less than 4000 km, while the maximum of the outer zone appears at about 16,000 km. Van Allen's estimates of the particle fluxes at the inner zone and outer zone maxima are given in Table 2. The outer zone extends out into space to a distance of around 55,000 km.

The inner zone of the radiation belt appears to be remarkably stable, showing very little variation with solar activity. In contrast, the outer zone fluctuates in radiation intensity and spatial extent. These fluctuations are directly associated with solar activity. Results from the Iowa, Chicago, and Minnesota groups obtained by means of Explorer satellites and Pioneer V provide some detail on this variation in the content and extent of the radiation belt. It has been found that, at the onset of a magnetic storm, the radiation intensity in the outer zone falls rapidly to a very low value. Simultaneously auroral displays in the earth's atmosphere appear. There then follows a rapid recovery in intensity which may build up to more than the prestorm level. Thereafter there is a gradual decline to the prestorm level.

Particle Radiation in Interplanetary Space

In addition to the cosmic radiation already discussed, interplanetary space contains the lower-energy particle radiation emitted by the sun. This radiation has not yet been observed in sufficient detail to determine fully its character. The instruments so far flown on deep space probes were incapable of recording particles of energy lower than 2 Mev for protons or 20 kev for electrons. Except at times of high solar activity the instruments recorded essentially the normal cosmic ray background intensity. Even at times of high solar activity the electron intensities were never as great as those observed in the radiation belt. A direct conclusion has been that the higher-energy electrons found in the radiation belt have acquired their energy by some local acceleration mechanism in the vicinity of the earth. The details of this mechanism have not yet been determined.

Thirty times in the past three years beams of protons have been detected over the polar regions following a large solar flare on the sun. These proton beams begin bombarding the polar caps of the earth approximately 1 hour after a flare of importance 2+ or greater has occurred on the sun. Not all flares of this magnitude, however, eject protons. The high flux may last from 10 to 100 hours. Of the 30 events so far observed, six were of such intensity and duration as to have given a lethal dose to an unprotected person in free space. Intensities of 5×10^8 protons per square centimeter per second for free space have been inferred by extrapolating balloon data to the top of the atmosphere.

Usually the number of particles decreases very fast as their energy increases. Thus a small amount of shielding causes a marked decrease in the dose rate. However, on at least one occasion a flat energy spectrum has been observed. The energy of the protons

Table 2. Van Allen's estimates on particle flux (9).

Heart of inner zone
(3600 km on geomagnetic equator)

(*a*) Electrons, $E > 20$ kev: maximum unidirectional intensity: $\sim 2 \times 10^6$ cm^{-2} sec^{-1} $ster^{-1}$

(*b*) Electrons, $E > 600$ kev: maximum unidirectional intensity: $\sim 1 \times 10^7$ cm^{-2} sec^{-1} $ster^{-1}$

(*c*) Protons, $E > 40$ Mev: maximum omnidirectional intensity: $\sim 2 \times 10^4$ cm^{-2} sec^{-1}

Heart of outer zone
(16,000 km on geomagnetic equator)

(*a*) Electrons, $E > 20$ kev: omnidirectional intensity: $\sim 1 \times 10^{11}$ cm^{-2} sec^{-1}

(*b*) Electrons, $E > 200$ kev omnidirectional intensity: 1×10^9 cm^{-2} sec^{-1}

(*c*) Protons, $E \sim 60$ Mev: omnidirectional intensity: $\sim < 10^2$ cm^{-2} sec^{-1}

(*d*) Protons, $E < 30$ Mev: no information

Fig. 2. Cosmic ray interactions with the earth's atmosphere.

varies from a few million electron volts to 700 Mev.

The frequency of these events varies over the 11-year cycle of solar activity. We have just passed through an extremely active period in which there was an average of ten per year. We are entering a period in which there will be at most perhaps one or two per year. The next period of high solar activity will begin in 1967.

The solar proton events are one of the major problems in the design of manned space vehicles. In the first place, their occurrence is presently unpredictable. In the second place, the magnitude and duration of the radiation level is also unpredictable.

Nature of the Radiation

Having discussed what radiations are encountered in interplanetary space and in the vicinity of the earth, let us now consider their fundamental nature. As stated earlier, all of the fundamental particles and quantum radiations, with the exception of the short-lived mesons, have been found in space. Table 3 shows the various kinds of particles and quantum radiations of particular importance. The electron and proton are both charged particles and along with the neutron form the three fundamental particles used to build ordinary atoms and molecules. The neutron flux in free space has not been measured, but it should be extremely small. The neutron lives only about 15 minutes, which limits the distance it can travel from its point of origin. The neutron spontaneously decays into a proton and an electron, both of which are stable particles. Gamma rays and x-rays are both high-frequency electromagnetic radiation. Gamma rays have the higher frequency, and since the amount of energy, the so-called photon or quantum of energy, which can be transferred to matter is proportional to the frequency, gamma rays have the higher energy. The exact energy which divides photons into x-rays or gamma rays varies, but generally it is taken as 1 Mev. Photons of energy >1 Mev are called gamma rays. They result from nuclear interactions and the so-called bremsstrahlung of electrons. X-rays are more easily absorbed and are produced primarily by electron bremsstrahlung. The heavier positively charged particles are found in cosmic rays. They penetrate into the atmosphere, down to about 80,000 feet, where they slow down and pick up a number of electrons equal to their charge and become ordinary neutral atoms.

Nature of the Interaction between Radiation and Matter

Radiation damage is done almost entirely by charged particles. As a charged particle travels through matter it exerts a force on electrons in the surrounding medium; the electrons move and thereby take up energy from the traversing particles. This process is called ionization because the removal of the electrons leaves positively and negatively charged ions in the surrounding medium. Neutral radiation, such as neutrons or photons, causes damage by first interacting with a charged particle, giving it sufficient energy to produce ionization. Large numbers of electrons are produced. A proton will liberate from 10^5 to 10^6 electrons per centimeter of path length in water.

The rate of ionization is proportional to the square of the charge on the particle and is inversely proportional to the square of its velocity. The rate of energy loss varies somewhat with the material through which the particle is traveling. This will be discussed in greater detail when we discuss shielding.

In addition to losing energy by ionization, an electron when decelerated will radiate gamma rays or soft x-rays. A proton of a given energy has a cor-

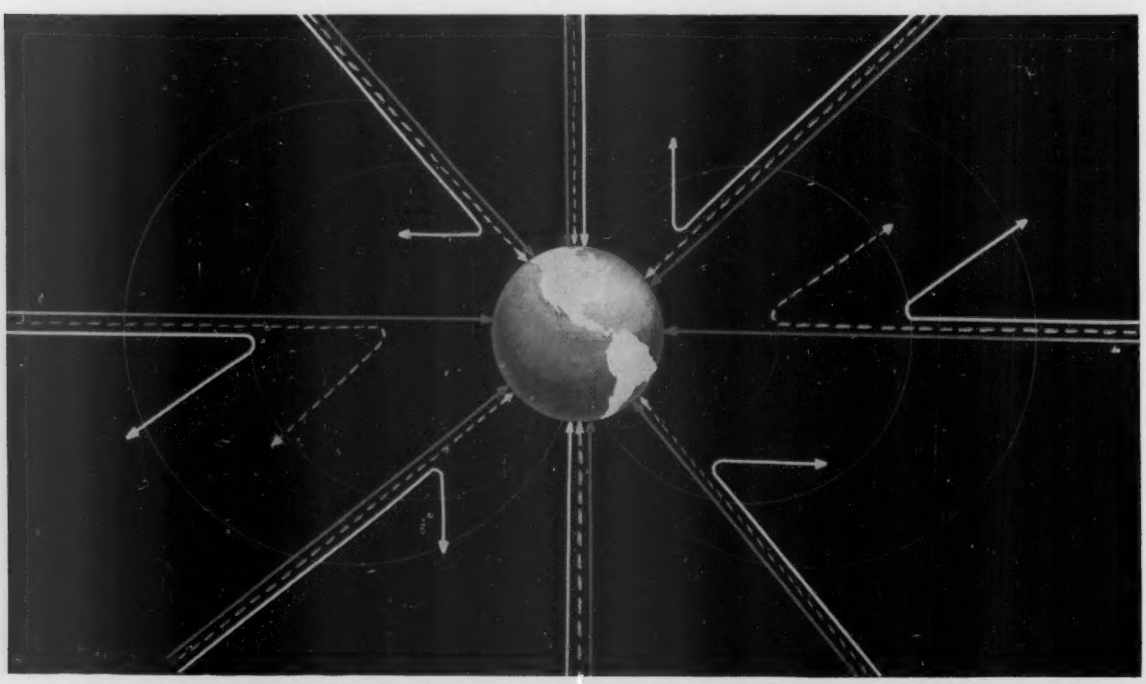

Fig. 3. Effect of latitude and altitude on cosmic ray intensity.

responding well-defined range in a given material. One gram of aluminum will stop a beam of 2.3-Mev electrons or a beam of 35-Mev protons. However, in the case of the protons a negligible amount of radiation would penetrate more than the 1 gram of aluminum, whereas for the electron a large amount of x-ray and gamma ray radiation that is produced would penetrate another 10 to 12 grams of aluminum. The exact mechanism by which the electrons liberated in tissue cause damage is complicated and not completely understood and will not be discussed in this article.

Table 3. Radiation in space.

Name	Nature of radiation	Charge	Mass	Where found
Photon	Electromagnetic	0	0	Radiation belts, solar radiation (produced by nuclear reactions and by stopping electrons)
Quantum	Electromagnetic	0	0	
X-ray	Electromagnetic	0	0	
Gamma ray	Electromagnetic	0	0	
Electron	Particle	$-e$	1 m_e	Radiation belt
Proton	Particle	$+e$	1840 m_e or 1 amu	Cosmic rays, inner radiation belts, solar cosmic rays
Neutron	Particle	0	1841 m_e	Vicinity of planets and sun (produced in nuclear interactions—decays into proton and electron)
Alpha particle	Particle	$+2\,e$	4 amu	Cosmic rays (nucleus of helium atom)
Heavy primaries	Particle	$\geqq +3\,e$	$\geqq$6 amu	Cosmic rays (nuclei of heavier atoms)

Radiation Dosage

The earliest measurements of radiation levels used an ionization chamber in which one applied a voltage between the outer shell and an inner electrode, thereby collecting the ions produced inside the chamber. A roentgen of radiation was that amount of radiation which would liberate one electrostatic unit of electricity in 1 cubic centimeter of air at standard pressure and temperature. Although there are later and more refined definitions of the radiation unit, we shall use only the roentgen as a measure of radiation levels. One other quantity is useful in discussing radiation; this is the so-called relative biological effectiveness, or RBE. This quantity measures the amount of damage caused by a given amount of radiation as compared to that caused by the same amount of radiation in the form of soft x-rays. For our purposes the RBE of the radiation in space can be considered as one.

Various radiation levels are given in Table 4. Twenty-five roentgens is the maximum permissible emergency dose which a man can take at one time, once in a lifetime. This is the dosage, for instance, which a man may be allowed to take to rescue an injured co-worker. After taking such a dose the man would not be permitted to take any more radiation in his lifetime.

Radiation Hazard

We shall now attempt to evaluate the radiation hazard to be encountered in space. In doing so we shall review the various areas discussed above—namely, electromagnetic radiation, cosmic rays, trapped radiation, and the background radiation in space.

Electromagnetic radiations. As stated above, radiation hazards and effects due to the electromagnetic radiations normally present in outer space are expected to be virtually negligible. This includes even the x-rays and gamma rays to be encountered. The principal hazard from electromagnetic radiations may be expected from those x-rays and gamma rays generated by the interaction of charged particles with material of the satellite or spacecraft. These hazards are discussed in connection with the particle radiations themselves.

Cosmic rays. The radiation dosage to be expected from the cosmic radiation is given in Table 4. It is clear that the dosage is quite small. There is, however, one aspect of the radiation effects from cosmic radiation which has not been entirely evaluated. Although the over-all integrated dose from the very heavy particles is small, a very intense exposure is given to a very small amount of material along the track of the individual particle as it stops. This problem can only be studied by exposing material to cosmic rays on high-altitude and high-latitude balloon flights. Experiments are continuing, in which, at present, no one has found biological damage which can be directly attributable to heavy cosmic ray primaries.

The total dosage in space from cosmic radiation is 5 to 12 roentgens per year.

Trapped radiation. We have seen that the radiation trapped in the earth's magnetic field consists of protons in the energy range from a few thousand electron volts to 700 Mev, and electrons from a few electron volts to about 1 Mev. Figure 5 shows the variation of radiation dosage with altitude along the trajectories of Explorers III and IV.

Freden and White (*1*), through analysis of nuclear emulsions exposed in recoverable ICBM nose cones, have shown that the flux of protons of energy greater than E is inversely proportional to E. This is a relatively slow fall off in flux with energy. Solar protons, for instance, fall off as the inverse 5th power of their energy (*2*).

The principal radiation hazard in the inner belt is from ionization produced by the high-energy protons. The principal radiation hazard in the outer belt is due to the soft x-rays produced as the electrons decelerate in the shell of a satellite or traversing spacecraft.

Radiations in space. Radiations in space consist of the cosmic rays, lower-energy electrons and other particles not yet observed by measuring instruments, and the solar proton beams of high-energy protons emitted by the sun dur-

Table 4. Maximum permissible radiation dosages and some typical exposure levels (in roentgens).

Item	Amount
Permissible exposures	
Maximum permissible dosages	0.3* r/quarter 5.0 r/yr
Maximum permissible emergency exposure	25 r
Typical exposures	
Normal radiation level (sea level)	0.001 r/day
Undisturbed interplanetary space (cosmic rays)	5–12 r/yr
Heart of inner belt (protons)	24 r/hr
Heart of outer belt (soft x-rays)	~200 r/hr
Solar proton event (protons)	10–10³ r/hr
Total exposure	2–400 r

* Limit prescribed for radiation workers. Under this limit the yearly maximum would be 1.2 r.

ing solar activity. The hazard due to the cosmic rays has already been estimated in preceding paragraphs; that due to the lower-energy particles cannot be evaluated until appropriate measurements have been made.

The hazard due to the solar proton beams can be a very serious one. By extrapolating balloon data to the top of the atmosphere, radiation levels as high as 3×10^4 roentgens (r) per hour have been inferred for free space.

Shielding Considerations

The protons in the inner Van Allen belt and in the solar cosmic radiations determine the weight and type of material required to shield a spacecraft. The incident electrons are easily stopped in the material required to shield against the protons; therefore, the major hazard from these electrons is the x-rays produced as they stop in the shield.

In order to reduce the radiation level inside a spacecraft to a tolerable level, while the spacecraft is traveling through the radiation belt or is immersed in a beam of solar protons, it is necessary to surround it with sufficient material to stop all protons below a certain energy. The choice of material depends upon whether space or weight is critical, the energy of the protons which must be stopped, and the size of the cavity. Table 5 shows the thickness of material and the weight per unit area required to stop 200-Mev protons as a function of atomic number. Liquid hydrogen is the best material from the standpoint of weight; however, due to its low density the size of a shield becomes formidable. Carbon is the next best material from the standpoint of weight, and the thickness of the shield is satisfactory. If space, not weight, were the deciding factor, or if the thickness of the shield is comparable to the dimensions of the cavity to be shielded, a metal such as tungsten would be useful. Obviously, fuel, which is a hydrocarbon, batteries, and other structural materials will have to be strategically placed in a spacecraft to provide a portion of the necessary shielding.

The number of x-rays produced by an electron of a given energy is proportional to the square of the atomic number of the stopping material. After production the rate of absorption of these same x-rays is also proportional to the square of the atomic number of the stopping material. An ideal shield against electrons would consist of a layer of liquid hydrogen, to stop the electrons while producing a minimum number of quanta, surrounding a layer of material of high atomic number to absorb the photons that are produced. An excellent substitute for such an ideal shield can be made by placing a thin (0.25 cm) layer of lead inside the carbon shield used to stop the protons, provided the range of the electrons is less than, or equal to, the thickness of the shield. The maximum energy of the electrons in the outer belt is of the order of 1 Mev. The range of a 1-Mev electron is 0.42 gram, which is a small fraction of the 5 g/cm^2 shield thickness required to stop the protons.

Keller and Schaeffer (*3*) have calculated the total integrated dose which a man would receive inside a spacecraft, shielded with 0.25 cm of lead surrounded by a 2 cm (5 g) thick layer of carbon, which followed the same trajectories as Pioneer III and Pioneer IV. The values are 0.6 and 12 r, respectively.

Implications for Space Missions

We have discussed the nature of the radiation and the properties of the natural phenomenon; now we will discuss the effect on space missions.

Of the three possible hazards—cosmic radiation, solar cosmic radiation, and trapped radiation—none will affect Project Mercury. The dosage from cosmic rays is reduced to 0.7 r per year due to the shielding effect of the magnetic field of the earth. This dosage is

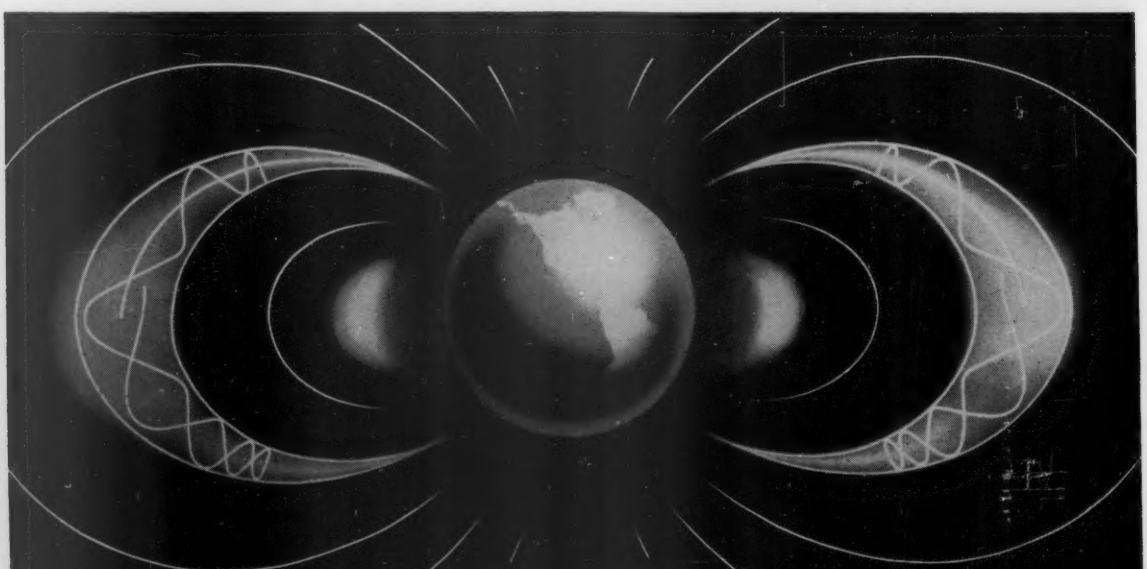

Fig. 4. Great radiation belts.

well within the prescribed tolerance. The slow, heavy nuclei have also been removed by the magnetic field. The actual number of particles which will strike an astronaut will be less than 5 percent of that which struck Colonel Simons during Project Manhigh. The orbit of Mercury lies below the inner belt; therefore, there is no danger from trapped radiation. The frequency of solar proton events will be down as the current solar activity declines. In addition, the magnetic field confines the protons from these events to the polar regions.

The trapped radiation and the solar cosmic rays are a hazard to those missions whose trajectories exceed an altitude of 500 kilometers or extend more than 60° north or south of the magnetic equator.

The radiation level inside the inner radiation belt exceeds 20 r/hr. The energy spectrum is flat; therefore, a large amount of shielding is required to protect a man in this region. It would require 45,000 pounds of shielding to reduce the radiation level to 0.5 r/hr inside a compartment 4 feet in radius. In 10 hours a man would receive his allowable yearly dose even with this amount of shielding. This would seem clearly to preclude manned observatories in this region.

The radiation level in the outer belt is high because of the bremsstrahlung produced by the electrons stopping in the outer shell of the spacecraft. The dose rate behind a 60-g/cm² carbon shield, due to the electrons in the outer belt, is about 1 r/hr. The addition of an inner layer of 0.25 cm of lead will reduce this dosage by a factor of 10. These figures are for the maximum in the outer belt and at a time of maximum intensity. However, again we can see that it is not possible to have manned vehicles in this region for extended periods of time.

In the region outside the radiation belts, the normal dosage will be the cosmic ray background level of about 5 to 10 r/yr. However, because of the solar cosmic rays, the solar proton beams, the shielding problem is complex. The outbursts of solar cosmic rays occur at random. At present, it is not possible to predict with certainty when such an event will occur; it is, however, possible by observations of solar activity to state that there is a high or low probability of an event within 4 or 5 days of the time of the observation. K. Anderson has worked up a method of prediction, based on the size of the penumbra of sunspots, that promises to be effective. Checks against past events are very encouraging (*4*).

Table 5. Shielding thickness for 200-Mev protons (thickness and weight per unit area, as a function of atomic number, for a shield which will just stop 200-Mev protons).

Material	Atomic number	Thickness (cm)	Wt. per unit area (g/cm²)
Liquid hydrogen	1	176	12.3
Carbon	6	12.9	29.0
Aluminum	13	12.1	32.7
Copper	29	4.4	39.0
Tungsten	74	2.7	52.0
Lead	82	4.6	52.0

The magnitude of the exposure varies from event to event and cannot be predicted as yet. Our knowledge of the phenomenon is limited by the recency of its discovery. Furthermore, the amount of additional data which can be obtained is limited to the next year. After next year, there will be almost no opportunities to obtain more experimental data until 1967. By 1967, plans and vehicle construction for the circumlunar mission will be well under way. Therefore, the shielding concept for this mission must be solved on the basis of the data presently available. There are a number of factors to be considered: Should the vehicle carry sufficient shielding to keep the radiation level in the spacecraft below 0.300 r per quarter (the maximum dosage for radiation workers) for the largest flux observed to date? This will require an immense amount of shielding and may, by displacing redundant control systems that would otherwise be built into the craft, subject the crew to additional hazards of a different nature. Perhaps only sufficient shielding should be provided to protect the man during passage through the radiation belts; and the solar proton events should be regarded as an emergency. A small shielded "storm cellar" would be provided with sufficient shielding to reduce the radiation level to a level such that the man would not receive more than the 25 r emergency dose. Interplanetary flights would then be scheduled when the probability of a solar flare is small, just as airline flights are routed around tornadoes.

Effects of the Radiation Environment on Materials

So far we have discussed the effect of the radiation on manned missions; before closing we would like to discuss the effects on materials. Generally, radiation dosages of 10^5 to 10^6 r are required to damage electronic components, and these dosages are not attained either from trapped radiation or solar cosmic rays. Therefore, as expected and observed, most electronic components will survive the radiation environment. However, an integrated flux of 10^{13} to 10^{15} 1.7-Mev electrons or 10^{10} 18-Mev protons on a square centimeter of solar cell will reduce the output to 75 percent of its initial value. Electrons of energy greater than 0.15 Mev and protons of greater than 0.2 Mev can cause damage to solar cells. Continuous exposure of bare solar cells in the center of the inner Van Allen belt could limit their life to a time which ranges from 6 hours to 5 weeks, depending upon

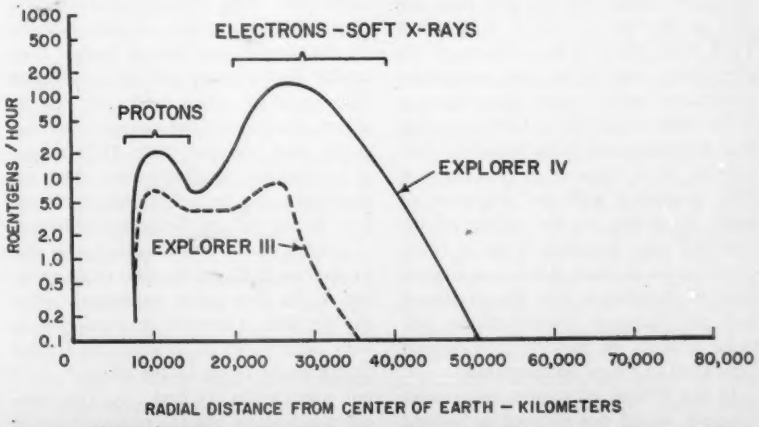

Fig. 5. Variation of radiation level along the trajectory of Explorer III and Explorer IV (*10*).

the proton flux which is assumed in the as yet unmeasured energy region below 40 Mev. The solar cells in Vanguard I are covered with a layer of glass and are still operating after 2 years of exposure to the inner belt. However, Vanguard I requires only a low-current drain, so that the full extent of damage may not be indicated in this case. In any event, this is not a very satisfactory method of eliminating the problem. Such a shield adds greatly to the weight of a solar power supply. Moreover, recent measurements by Denny (5) have shown that 10^{10} protons, of 350 to 750 Mev, per square centimeter, will also lower the efficiency of solar cells by 25 percent. Against such particles glass shields of reasonable thickness would be ineffective. Clearly, research and development are required to produce long-lived solar power supplies for use on satellites that must operate for long periods within the inner radiation belt. On the observational side, further measurements must be made in the 0.5- to 10-Mev region of the proton spectrum in the Van Allen belts to determine the exact shielding required.

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Science in the News

John Kennedy's New Frontier: "The Margin Was Narrow but the Responsibility Is Clear"

The president-elect will take office with a mandate granted him by 50.2 percent of the major party voters and a Democratic majority of about 80 seats in the House of Representatives. Roosevelt in 1932 had 59 percent of the major party vote and a margin of 191 seats in the House. Kennedy has other disadvantages: he would not have won the election without the support of the conservative South; the country does not face as obvious a crisis as it did when FDR took office at the bottom of the depression; and before the nominating convention and to some extent today it is the more conservative Johnson rather than Kennedy who is the favored candidate of most Democrats in Congress. This, combined with the suspicion, or hope, depending on the politics of the observer, that Kennedy is really fairly conservative at heart has led to a good deal of speculation that the likelihood that the Kennedy administration will make a mark in history as a second New Deal can now be dismissed.

In the field of education, this means Kennedy would not succeed in putting through a massive program of federal support for public and higher education, for improving the economic position of teachers at all levels, and for removing the financial and social barriers that prevent or discourage students from poor families from going on to college and graduate school. In science, it suggests that there will be no abrupt increase in the current rate of growth of federal support for research.

Those who take the view that Kennedy's New Frontier can now be dismissed as campaign talk see his administration following a line close to that associated with Nixon: more active Presidential leadership; a faster increase in the size of the federal budget than under Eisenhower, but still increases that could be called moderate; and an effort to revitalize the government with newer and younger men. They expect a progressive administration, but not one that could be called radical by anyone to the left of Senator Goldwater.

Among those who disagree with this evaluation is Kennedy, who told reporters in his first press conference after the election: "I went to the country with very clear views as to what the United States ought to do in the sixties. . . . I am going to do my best. . . . The margin was narrow but the responsibility is clear." And in a speech last January, the tone of which has been repeated frequently since, Kennedy told the National Press Club that the Presidency requires strong leadership by a man who is willing to risk incurring "the momentary displeasure" of the public he is serving. Kennedy, in turn, is supported by Harry Truman who, in a syndicated article published this week, pointed out that both Lincoln and Wilson were elected by a minority of the popular vote, a fact which discouraged neither from the strongest sort of Presidential leadership.

Congress

Part, but only part, of the difficulty the new administration will face is that some of the ideas Kennedy and his advisers have talked of will be opposed as being too radical in themselves: Kennedy will probably have little trouble getting almost anything he wants from the Senate; the test will come in the House, where there is strong opposition in principle to a program like the plan for federal aid to teacher salaries, with its implied threat of the passing of a good deal of the basic responsibility for the country's educational system from the local to the federal government; to health insurance for the aged under social security, with its threat of eventual expansion to provide federal health insurance for everybody; to the Kennedy proposal on minimum wages with its intent to broaden federal regulation of wages and hours from the present control over businesses "involved" in interstate commerce to businesses "affecting" interstate commerce—that is, to almost every business of any consequence.

The Senate passed two of these proposals during the last session, and the third, health insurance tied to social security, probably would have passed if

the imminence of the election had not kept the liberal Republicans from backing Kennedy. But none of these proposals had any chance of getting through the House in the face not only of the House's greater conservatism but of the opposition of the Rules Committee and the near-certainty of an Eisenhower veto if they were to pass. The House will be more conservative in its membership after January. Twenty-two northern Democrats have been replaced by Republicans, nearly all conservatives, and this situation in the House is the source of much of the confidence of those who feel that much of Kennedy's New Frontier can now be written off in advance. Whether this is actually the case will depend on Kennedy's ability, completely untested as yet, to use the powers of the Presidency.

Kennedy's problem is enormous. Pushing through positive programs which the conservative coalition in the House might regard as too radical is only part, and probably the lesser part, of the task he faces. For it all costs money, and the money has to be raised. Many of the most expensive parts of the Kennedy program—space, defense, scientific research—are not "liberal" or "conservative" programs, although these three areas alone could well add an extra $4 billion to the first Kennedy budget.

One of the advantages, from the Kennedy view, of his farm and medical insurance programs is that both would be paid for in part by money raised outside the regular federal budget—the medical plan through the social security tax, the farm plan through higher food prices. Again, one of the advantages of the Democratic promise to lower interest rates is that it would save some money (Kennedy has talked of as much as a billion a year) on servicing the national debt, an expense which now runs to about $7 billion a year.

If Kennedy can get his way on these programs there is still a considerable range of additional measures that he needs to push through Congress in order to pave the way for getting enough money to carry both the additional expense for national security programs (space, defense, foreign aid) and for his domestic programs (urban renewal, distressed areas assistance, aid to education, and many more). He can get this money in three ways: outright tax increases, closing tax loopholes, and encouraging economic growth. Tax increases, of course, are unpopular. Closing loopholes is popular with the country at large, but very unpopular with the people whose loopholes are being closed, and who are assured of a friendly hearing before the conservative tax committees of the House and Senate. Stimulating economic growth is highly popular in principle, but in practice it requires a series of much less popular measures to enable the government to keep the economy at or very near full employment most of the time while having some control, direct or indirect, over prices and wages to prevent a runaway inflation from developing.

Thus Kennedy, if he is to carry out his promised program, is faced with the task of pushing through its positive aspects, some of which will be considered too radical by a substantial number of Congressmen; with the task of pushing through supporting legislation to make it possible to raise the money to pay for the programs, some of which again will be considered too radical by a substantial number of Congressmen; and on top of all this with the need to push through a considerable amount of other legislation—some reorganization of the defense department, revision of the conflict of interest laws, salary revision for the higher levels of the government, more adequate expenses for ambassadors, and several dozen other measures—all of which, while they cannot be criticized as too liberal or too expensive, nevertheless must face considerable opposition, if only in the form of Congressional inertia, and all of which will require the expenditure of a certain amount of Presidential energy to put across.

It was never believed that it would be an easy matter for Kennedy to push his program through. The slim margin of victory and the loss of liberal strength in the House have added to the difficulty, but have not made the difficulties insurmountable.

No one can tell yet how many votes can change in the House simply because Kennedy will be in the White House pleading the case for what must be done, while Eisenhower used the vast influence of the Presidency to warn the public of the danger of spending too much money. Nor can any one tell how many Congressional votes Kennedy can win through the use of the grosser tools of politics which Eisenhower always shied away from—the numerous jobs and favors which the President has the power to grant or deny.

No one is sure what role Johnson will play. Kennedy needs Johnson's active support more than ever. But Johnson's conservatism may well be overcome by his well-known ambition to make a name for himself as a major national figure. If Johnson becomes convinced that the way to make his mark in history is as a man who helped mightily to make it possible for Kennedy to put his program through in the face of great obstacles, rather than as an essentially negative figure, then Johnson may well turn out to be of far more assistance to Kennedy than has been expected. It was a similar appeal to the man's pride and sense of his role in history that helped convert Senator Vandenberg from a pre-war isolationist to the great Republican exponent of a bipartisan foreign policy in the decade of the 1940's.

But Kennedy's greatest source of strength is likely to be the existence of a powerful coalition of leaders, not only in politics and public affairs, but in the press, the universities, finance, and labor, who publicly or privately agree with Kennedy that the country faces an enormous challenge in the coming years, and that strong action is needed to meet the challenge. These are men who, among Republicans, were able to support Nixon only because they were convinced that his position was a great deal closer to Rockefeller's than to Eisenhower's. Most of these men, even the Republicans among them, would have been appalled at the thought of another Eisenhower administration. The Gaither, Coolidge, and Rockefeller reports were all prepared by good Republicans who found as harsh things to say about the Administration as anything Kennedy has said. In the area of national security, which includes the problem of economic growth, science, and much of the Kennedy program for education, as well as defense and foreign affairs, Kennedy expects to be able to enlist the support of such men. He made it clear that he intended to offer them posts in his administration long before the election returns made such action so clearly necessary.

How much Kennedy will accomplish is anybody's guess. But it is very possible that he will accomplish a great deal. The great bulk of his program lies in areas that are associated with national security, and another large share lies in areas such as urban affairs, where the problems have been getting worse for years and where it is really not very difficult to build a case for federal action to help solve them.—H.M.

News Notes

Lysenko's Influence on Soviet Biological Sciences Waning

The Soviet Union, which in the early 1930's held world leadership in soil science and cast it aside to adopt the politically desirable but scientifically unsound theories of T. D. Lysenko, gradually is breaking this scientist's strangle hold on the biological sciences, including medicine, that was made possible through Stalin's support. This is reported in *Lysenko, Michurinism, and Soviet Biology*, an 8-page summary and evaluation of available Russian information recently released by the Office of Technical Services, Business and Defense Services Administration, U.S. Department of Commerce.

The document reports on the ideological revolution occurring in Russia over the validity of the long-accepted "Michurin science" advocated by Lysenko and endorsed by the Communist party because it conformed with Marxist ideology, as opposed to the theories of Russia's "classical geneticists," whose research theories follow the accepted concepts of biologists in other nations.

Although still officially recognizing Lysenko, the Soviet Government is encouraging the free discussion of biological theory, says the report, even if it involves Marxist-Leninist doctrine. Prior to the 1930's, the report states, Soviet plant genetics and breeding research was of outstanding quality and soil science was more highly developed than in the United States and other Western nations.

The report traces the rise of Lysenko from 1935 to a position of near-absolute authority in biological research and his subsequent decline in influence following the death of his mentor, Stalin. The arguments of Lysenko's significant critics are summarized, including those of N. P. Dubinin, who blames the Party-backed biologist for the lack of corn hybrids in the U.S.S.R. Dubinin, a world-renowned geneticist whose work has been ridiculed by Lysenko and whose cytogenetics laboratory was abolished in 1948, has advanced a program for the use of inbred lines of corn to produce hybrids that is now being largely adopted in the state-wide system of hybrid seed-corn production endorsed by Khrushchev. However, Khrushchev still defends Lysenko's views on soil problems and considers his recommendations at the practical agricultural level of value, says the report.

The following paragraph from the report is indicative of the Soviet Government's more liberal policy toward new theories in biology and related sciences.

"Soviet periodicals reflect a much greater cognizance of world developments in biological and agricultural research, and efforts are being made to adapt foreign research findings to Soviet conditions. Partial or complete translations of modern Western research works and texts in various fields of biology are appearing in increasing numbers."

The gradual change from Lysenkoism to sound fundamentals, together with high-level statements on the future direction of Soviet biology, indicates that present and future biological research will be influenced principally by scientific fact rather than by the unfounded interpretations of politically minded biologists. The report goes on to predict that Russian research will probably follow an approach to genetics similar to that of Western countries. The result should be a marked improvement in genetics research in the U.S.S.R. The author concludes his report by stating that Russia's improved research capability and the wide application of Western research achievements should boost agricultural production. (The report may be obtained for 50 cents from the Office of Technical Services, Dept. of Commerce, Washington 25.)

Seismic Station Completed; Follows Pattern Set at Geneva

A new seismic research station designed to study the problem of detecting and identifying both earthquakes and underground chemical and nuclear explosions has been completed at Fort Sill, Okla. The station, to be called the Wichita Mountains Seismological Observatory, is part of the United States seismic improvement program known as Project VELA-Uniform.

This station fulfills the original conditions outlined by the international Conference of Experts—consisting of representatives of the United States, the United Kingdom, France, Canada, the U.S.S.R., Romania, Czechoslovakia, and Poland—which met at Geneva, Switzerland, in 1958 to "study the possibility of detecting violation of a possible agreement in the suspension of nuclear tests." The equipment that has been installed is identical to that recommended by the Geneva conference. This is the first such prototype facility to be established. It is located in the Wichita Mountains, about 15 miles northwest of Lawton, Okla., on a site that was selected because the minute vibrations of the earth—called "microseismic noise"—which interfere with the detection of signals from distant earthquake or underground nuclear explosions are exceptionally small in the area.

Evaluation of the station's performance will be open to the scientific community and to delegates of the United States, the United Kingdom, and the U.S.S.R. who are now negotiating in Geneva in an effort to arrive at a treaty on the controlled cessation of nuclear weapons testing.

The Wichita Observatory has been developed and will be operated by the Geotechnical Corporation of Garland, Tex., under the technical supervision of the Air Force Technical Applications Center. The program is under the overall direction of the Department of Defense's Advanced Research Projects Agency.

Project VELA's Three Parts

ARPA's Project VELA, announced by the Department of Defense on 2 September 1959, is subdivided into three categories: (i) VELA-Uniform, research and development concerned with detection of underground nuclear explosions; (ii) VELA-Sierra, research and development concerned with the ground-based detection of nuclear tests in space; and (iii) VELA-Hotel, research and development concerned with satellite-based detection of nuclear tests in space. The program was developed by ARPA in collaboration with the Atomic Energy Commission, the National Aeronautics and Space Administration, the Departments of Commerce and Interior, and the Department of the Air Force.

Helminthological Society Observes 50th Anniversary

Last month the Helminthological Society of Washington observed its 50th anniversary by presenting a scientific program at the University of Maryland. The morning and afternoon sessions were attended by 260 scientists from the United States, Canada, Europe, Asia, and Australia.

The principal event of the evening

Chauncey D. Leake (center) speaker of the evening at the 50th anniversary celebration of the Helminthological Society of Washington, with George W. Luttermoser, president of the society (right), and A. O. Foster, toastmaster.

program, following a banquet, was an address by Chauncey D. Leake of Ohio State University, president of the AAAS, entitled "Paralogue and Parasite."

Two awards were presented. One was to Miss Edna M. Burher in recognition of outstanding service to the society during 25 years as secretary-treasurer. The other, granted by the trustees of the Brayton Howard Ransom Memorial Fund, went to James Turner "for meritorious service to parasitology and related sciences."

International Brain Research Organization Created in Paris

UNESCO has announced the creation of an International Brain Research Organization, the purpose of which is to coordinate results and facilitate training and research in this branch of science. The announcement followed a 4-day meeting last month at UNESCO House in Paris.

The meeting brought together 18 scientists, from 12 countries, who are serving as members of a central committee representing the seven principal branches of brain research: neuroanatomy, neuroendocrinology, neurochemistry, neuropharmacology, neurophysiology, the behavioral sciences, and biophysics. The meeting was convened on behalf of UNESCO by the Council for International Organizations of the Medical Sciences. Committee members came from Argentina, Australia, Canada, France, the Federal Republic of Germany, Italy, Norway, Poland, Sweden, the United Kingdom, the U.S.S.R., and the United States.

At the meeting the statutes of the new international nongovernmental organization were adopted and an executive committee was elected. H. H. Jasper of Montreal, a noted neurophysiologist, was chosen executive secretary of the committee. Other committee members elected are: P. K. Anokhin of the U.S.S.R., A. Fessard of France, G. W. Harris of the United Kingdom, H. W. Magoun of the United States, Giuseppe Moruzzi of Italy, and Heinrich Waelsch of the United States. D. Bovet of Italy, A. Brodal of Norway, and W. A. Rosenblith of the United States were chosen as alternate members.

AAAS Human Welfare Group To Hold Open Hearings

The AAAS Committee on Science in the Promotion of Human Welfare invites the participation of AAAS members in two open hearings which it plans to hold during the course of the Association's annual meeting in New York. From 4 to 6 P.M. on Wednesday afternoon, 28 December, the committee will meet in the grand ballroom of the Biltmore Hotel to hear discussion of "The Expansion of Medical Research," especially as it relates to the interactions between public policy and the development of science. A second meeting, from 3 to 6 P.M. on Friday afternoon, 30 December, will be concerned with "The Effects of the Present Status of Science on the Integrity of Science."

The committee is interested in providing an opportunity for the expression of various viewpoints on these questions. Scientists who would like to make brief presentations (approximately 10 minutes in length) before these hearings should send a short summary of their proposed remarks to the chairman of the committee, Barry Commoner, Washington University, St. Louis 30, Mo., *by 5 December*. All registrants at the annual meeting will, of course, be welcome at the hearings.

News Briefs

TV program on genetics. "The Thread of Life" on NBC-TV, 9 December, will be a 1-hour program in color devoted to genetics. This is the newest program in the Bell System Science Series. The "thread" of the title is the continuity of heredity from generation to generation, and the program surveys the processes by which this is accomplished. The functions of genes and chromosomes are explained, and the operations of mitosis and meiosis are demonstrated.

Of special interest is Harriett Ephrussi-Taylor's discussion of the role of deoxyribonucleic acid in heredity. In another section of the program, Andrzej Bajer demonstrates the technique he used in stop-motion cinemicrography of mitosis.

James F. Crow of the University of Wisconsin and Norman H. Horowitz of California Institute of Technology served as special advisers for the production.

* * *

Canadian plant physiology. The Canadian Society of Plant Physiologists now has a category of corresponding membership available at a nominal fee to plant physiologists who live outside Canada. Inquiries should be directed to the Secretary-Treasurer, Dr. D. F. Forward, Department of Botany, University of Toronto, Toronto 5, Canada.

* * *

Ford and radiation hazards. Grants to three international scientific bodies have been announced by the Ford Foundation to help speed up the task of defining, measuring, and limiting the hazards resulting from man-made radiation. The International Commission on Radiological Units and Measurements will receive $185,000 to assist in improving the measurement of

radiation received by living matter; the International Commission on Radiological Protection will receive $250,000 to assist in determining objective safety standards for human exposure to radiation; and the International Bureau of Weights and Measures will receive $32,500 to accelerate planning of a major effort to establish world-wide standards of radiation measurement.

* * *

Neutron cross section center. The Atomic Energy Commission has established a Neutron Cross Section Evaluation Center at the Brookhaven National Laboratory to provide a centralized source of information on neutron cross section data needed by reactor engineers, designers, and physicists. Information will be available to the nuclear industry. Requests will be filled on a schedule of priorities based on the general importance of the data required and their availability. A fee may be charged if a request requires more than providing information which is readily available. Inquiries regarding cross section information should be directed to: Brookhaven Cross Section Evaluation Center, Building T-130, Brookhaven National Laboratory, Upton, N.Y.

* * *

Canada builds atomic center. Atomic Energy of Canada Limited has announced that a village to accommodate employees of the company's Whiteshell Nuclear Research Establishment will be built about 60 miles northeast of Winnipeg. AECL reported a year ago that it would establish a nuclear research and development center in Manitoba rather than expand the Chalk River establishment, which is considered to be near maximum size for efficient operation.

The new village will not be a "company town" but will be a local government district under the jurisdiction of the Department of Municipal Affairs of the Manitoba Government. The Whiteshell establishment will concentrate on power reactor development, and the facility to be built there is likely to be a reactor cooled by an organic liquid and moderated with heavy water.

* * *

Endocrinologists to meet. The third International Symposium on Comparative Endocrinology, sponsored by the Zoological Society of Japan, will be held 5–10 June at Oiso, near Tokyo. Because of limited seating capacity and housing accommodations, advanced registration is required. The speakers have been invited, and the program is already set.

The international committee members of the symposium include: E. J. W. Barrington (England), W. R. Boss (Japan), I. Chester-Jones (England), M. Fontaine (France), L. Gallien (France), A. Gorbman (U.S.), B. Hanström (Sweden), C. Barker Jørgensen (Denmark), P. Karlson (Germany), H. Kobayashi (Japan), G. J. van Oordt (Netherlands), K. Takewaki (Japan), and E. Witschi (U.S.). For information, write to the symposium chairman, Dr. Kiyoshi Takewaki, Department of Zoology, University of Tokyo. The general secretary is Hideshi Kobayashi of the same department.

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Australian scientist recruitment. A spokesman for Australia's Federal Bureau of Mineral Resources reported recently that the bureau had overcome its long-standing shortage of geologists, geophysicists, and technicians. The bureau is engaged on important work in connection with the search for oil in Australia, and is also assessing Australia's mineral resources. In recent years the bureau had not been able to recruit even its minimum requirements of scientific staff; however, the gain of new staff over resignations during the past year has been 9 geologists, 13 geophysicists, and 12 scientists in various other fields.

New Journals

Nuclear Hazards Newsletter, No. 2, July 1960. C. F. Powell, President, World Federation of Scientific Workers, 40 Goodge St., London, W.1. Irregular.

Engelhard Industries Technical Bulletin, vol. 1, No. 1, June 1960. Miss L. A. Magistrate, Ed. Engelhard Industries, Inc., 75 Austin St., Newark 2, N.J. Quarterly.

Midway, No. 3. F. Holton, Ed. University of Chicago Press, 5750 Ellis Ave., Chicago 37, Ill. Quarterly. $1. $3.50 per year.

Mineragraphic Investigations Technical Paper No. 1. CSIRO, University of Melbourne, Parkville, N.2., Victoria, Australia. Irregular.

Index Chemicus, vol. 1, No. 1, 1960. E. Garfield, Ed. Institute for Scientific Information, 1122 Spring Garden St., Philadelphia 23, Pa. Monthly. $250 educational; $500 industrial.

Acta Medica Costarricense, vol. 1, No. 1, Dec. 1957. R. F. Cespedes, director. Apartado 4054, San José, Costa Rica. Three issues per year. $2.

Safybi, No. 1, 1959. Z. M. Lugones, director, Sociedad Argentina de Farmacia y Bioquimica Industrial, Tacuara 1428, Buenos Aires.

Grants, Fellowships, and Awards

Atomic energy. The Oak Ridge Institute of Nuclear Studies has announced that *15 December* is the deadline for receipt of applications from university scientists for appointments to the Oak Ridge Research Participation Program. Under the program, college and university scientists receive their regular academic salary for conducting research in Oak Ridge laboratories. A housing allowance is also available in certain circumstances.

Appointments are usually made for the three summer months, but other appointments can be arranged. Appointments are available in virtually all fields of scientific endeavor, and the scientific interest of the applicant will determine the laboratory for which he is considered. Application forms and further information are available from the Research Participation Office, Oak Ridge Institute of Nuclear Studies, Box 117, Oak Ridge, Tenn.

Industrial medicine. The Atomic Energy Commission is offering eight fellowships for 1961–62 to provide advanced training and on-the-job experience in industrial medicine, particularly in relation to the atomic energy industry. The program, which is administered by the University of Rochester, is open to men and women physicians who are citizens of the United States, who have graduated from an approved college of medicine at least 2 years prior to beginning tenure of the fellowship, and who are licensed to practice medicine in one of the states or territories of the United States. Successful candidates will be required to have a full background investigation by the F.B.I.

The training program consists of two parts: (i) an academic year at a university offering an approved graduate course in industrial medicine, and (ii) an in-plant training year, in which the fellow will be assigned to one or more of the medical departments of the major operating plants and laboratories under the direction of the Atomic Energy Commission.

The stipend during a fellowship or academic year is $5000. The sum of

$350 is added to the total stipend for a wife, and $350 more is added for each dependent child. Tuition and laboratory fees which would be required of students of similar university status will be paid in academic courses. Certain other expenses incident to the work of the fellow will be paid when approved by the committee. During the in-plant year the stipend is paid by the plant. A minimum of $7500 is recommended. Address all inquires to: A.E.C. Fellowships in Industrial Medicine, Atomic Energy Project, University of Rochester, School of Medicine and Dentistry, Rochester 20, N.Y. Attn: Dr. Henry A. Blair. Application deadline is *1 January 1961*.

O.E.E.C. Applications are now being accepted for Organization for European Economic Cooperation senior visiting fellowships for 1961. About 25 awards will be made to United States citizens under a program administered by the National Science Foundation. The fellowships are designed to assist institutions in sending senior staff scientists, mathematicians, and engineers to study new techniques and developments at advanced research and educational institutions primarily in the O.E.E.C. member countries or in countries co-operating with that organization. The fellowships will usually be for periods of from 8 weeks to 6 months; in exceptional cases a maximum period of 1 year may be approved. The program will allow study in most fields of science and technology. Awards will not be made in this program for work in the social sciences or in medicine. A candidate must be nominated by his institution. The ability of each applicant will be evaluated for the National Science Foundation by panels of scientists appointed by the National Academy of Sciences–National Research Council.

Each fellow will receive a subsistence allowance of $10 a day. A travel allowance covering the cost of air-tourist transportation to the fellowship institution and return will also be provided. In addition, the fellow will be permitted to receive, during the period of his award, his regular salary or appropriate allowances provided by or approved by his nominating institution, or both.

Applications and detailed information may be obtained from the Fellowship Office, National Academy of Sciences–National Research Council, 2101 Constitution Avenue, NW, Washington 25, D.C. Applications must be received not later than *6 January 1961*.

Plastics. Princeton University offers graduate fellowships in its plastics program, which is unique in the United States. The program provides graduate engineering study and fundamental research in plastics, leading to the degree of master of science in engineering; it is particularly suited to chemical, electrical, and mechanical engineers and to chemists and physicists. Stipends range from $1500 to $2100, plus tuition fees. Opportunities for employment as half-time research assistants to $2100 per academic year are also available, to students not on fellowships. For further information, write to Prof. Louis F. Rahm, Director, Plastics Laboratory, Princeton University, Princeton, N.J.

Radiation biology. The Bowman Gray School of Medicine is beginning a training program in radiation biology and cancer-related research. Traineeships of from 1 to 3 years are being offered to research-oriented people in the basic and clinical sciences. The traineeships are for training at both predoctoral and postdoctoral levels, and stipends will range from $1800 to as much as $8000 per annum. Applications are being accepted now for work to begin in January 1961 and will be accepted until *15 April 1961* for programs to begin 1 July 1961. Inquiries should be directed to Donald J. Pizzarello, Executive Director, Radiation Biology and Cancer Related Research Training Program, Bowman Gray School of Medicine, Winston-Salem, N.C.

Secondary school teaching. The National Science Foundation has announced that fellowships for secondary school teachers of science and mathematics will be made to several hundred teachers for summer study beginning in 1961 and continuing for as many as three successive summers. The fellowships will be awarded competitively to support individually planned programs of study on the advanced-degree level in the mathematical, physical, and biological sciences at institutions chosen by the fellows. Fellows will not, however, be required to follow courses of study leading to degrees. (The fellowships are in addition to the foundation's regular program of support of summer and academic year institutes in which groups of teachers take courses specially designed for them.)

An applicant for the secondary school teachers program must be a United States citizen with a baccalaureate degree or its equivalent and at least 3 years of secondary-school teaching experience. Applicants will be evaluated by panels of scientists appointed by the American Association for the Advancement of Science.

Stipends will be computed at the rate of $75 for each week of tenure. Travel and dependency allowances will normally be provided, and the foundation will pay tuition and required fees.

Teachers should *not* submit applications to the National Science Foundation. Information and application materials may be obtained by addressing a request to Secondary School Fellowships, AAAS, 1515 Massachusetts Ave., NW, Washington 5, D.C. Completed applications must be received by the association by *6 January 1961*. Fellows will be notified by 15 March.

Soviet study. The Inter-University Committee on Travel Grants, representing a number of American universities, is soliciting applications and inquiries from qualified persons concerning the fourth year of long-term exchange of advanced graduate students and young scholars with the Soviet Union (1961–1962). An applicant must be an American citizen, not over 40 years of age and must be either a graduate student, a postdoctoral researcher, or a young faculty member of a university. Applicants in the field of Russian studies must be proficient in Russian; applicants in other fields, if they are not proficient in Russian, must be willing to undertake intensive summer study of the language. Applicants from all fields of study will be considered; however, there must be a reasonable professional benefit to be derived from the proposed study in the Soviet Union.

The amount of aid provided will be determined by the applicant's own financial situation. Fellowships from other sources can be applied toward participation in this program.

This interuniversity project was formerly administered by Columbia University. For further information and applications write to: Inter-University Committee on Travel Grants, Box 70, Indiana University, Bloomington, Ind. Applications must be received by *5 January 1961*.

Teacher training. Stanford University, with the financial support of the Shell Companies Foundation, Inc., and the Shell Oil Company of Canada, Ltd., is again making available to secondary-school chemistry, physics, and mathematics teachers 50 Merit Fellowships which provide an opportunity for ad-

vanced study in their teaching fields. Under these fellowships a teacher may attend a Stanford University summer session at practically no cost to himself. The fellowships provide full tuition, board, and room; textbook and travel allowances; and a cash stipend of $500. The total value of a fellowship is approximately $1350 for the 8-week summer session.

To be eligible, an applicant must have a bachelor's degree and must have taught for at least 5 years. For information, write to Dr. Paul DeHart Hurd, Coordinator, Shell Merit Fellowship Program, Stanford University, Stanford, Calif. Applications should be submitted as soon as possible; all forms, recommendations, and transcripts must be received by *4 January 1961*.

Scientists in the News

Victor F. Weisskopf, theoretical physicist, professor of physics at Massachusetts Institute of Technology, and current president of the American Physical Society, has been appointed a scientific director of CERN, the 13-nation European Organization for Nuclear Research with headquarters near Zurich, Switzerland. The appointment, announced officially on 4 November, is considered unusual because Weisskopf is an American citizen and the United States is not a member of CERN. On 21 October this department quoted Walter Sullivan of the New York *Times* as having said that Weisskopf would "head" CERN. Actually, Sullivan said that Weisskopf would be scientific director.

Since that time, it has been announced that Weisskopf will be a member of a newly formed five-member directorate created by the 13-nation council which acts as a steering committee to the center.

Gilberto Bernardini of Italy has also been appointed a scientific director. Director-general is **John B. Adams** of England, but there is a report that he will resign soon to head his country's research on controlled nuclear fusion. In addition, the new directorate will have an administrative director and a director in charge of applied physics, both still to be named.

Robert Cushman Murphy will deliver the Isaiah Bowman Memorial Lecture at a dinner of the American Geographical Society on 1 December at the St. Regis Hotel in New York. Murphy is emeritus Lamont Curator of birds of the American Museum of Natural History and has been associated with the museum since 1906. He is an authority on oceanic birds. Early this year he served as chief zoologist on the U.S. Navy's Operation Deep Freeze, 1960, in Antarctica. His address will deal with oceanography and its importance to man, now and in the future.

At Northwestern University Technological Institute, new faculty members include the following.

J. Wallace Givens, formerly chairman of the mathematics department at Wayne State University, who holds a joint appointment as professor of engineering sciences in both the engineering sciences and mathematics departments.

John Jacobs, formerly manager of a research laboratory at General Electric's X-Ray Division in Milwaukee, professor of electrical engineering.

Makoto Itoh, professor of electrical engineering at Kyushu University, Japan, who will spend this year at the Institute as visiting professor of electrical engineering.

Donald M. Ross of the department of zoology, University College London, will join the department of zoology at the University of Alberta (Canada), as professor and head, in January 1961. Ross' recent research has been in the field of behavior and neurophysiology, particularly in the coelenterates.

Victor Hicks, formerly chief physicist for the Allen-Bradley Co., Milwaukee, Wis., manufacturers of electronic components, has joined the Remington Rand Univac military department in St. Paul, Minn. Since 1958, in addition to his other duties, he has served as research professor of physics at Marquette University (Milwaukee).

Wilbur M. Benson, former professor of pharmacology at the University of Minnesota Medical School, has been appointed director of pharmacology in the Mead Johnson and Company Research Division, Evansville, Ind.

Colonel **Richard K. Jacobson** has been appointed director of information for the Air Research and Development Command, Andrews Air Force Base, Washington, D.C. Jacobson, former deputy chief of ARDC's Command Policy Office, succeeds Colonel **William S. Evans**, who assumed new duties as assistant director of information, Office of the Secretary of the Air Force.

Joseph R. Feldmeier has been named associate director of research in the Philco Corporation's Research Division, Philadelphia, with responsibility in the long-range planning of technical programs and the identification of new areas of science and technology of value to Philco. Since 1952, he has been associated with the Bettis Atomic Power Division of the Westinghouse Electric Corporation, where he directed research programs in nuclear energy.

Donald J. Ferguson, formerly Chief of Surgery, Veterans Administration Hospital, Minneapolis, and professor of surgery at the University of Minnesota, is now professor of surgery at the University of Chicago.

J. E. Wallace Wallin, retired state director of special education and mental hygiene of Delaware, was recently awarded a scroll by the New Jersey Psychological Association and the New Jersey Department of Institutions and Agencies for his achievement as a "pioneer psychologist who, with rare foresight and understanding, established in 1910 at the New Jersey Village for Epileptics the first State Psychological Laboratory."

Captain **Louis S. Hansen** (DC) U.S.N., has been appointed chief of the Dental and Oral Pathology Division at the Armed Forces Institute of Pathology, Washington, D.C. He is the first naval officer to head an institute division. Hansen relieves Major General **Joseph L. Bernier** (DC) U.S.A., who was recently detached to assume the duties of chief of the Army Dental Corps.

Josef DeLey, professor and director of the Laboratory of Microbiology, Rijksuniversiteit, Ghent, will be visiting professor of microbiology, University of Illinois, Urbana, from February through May 1961.

Hugh J. Miser, formerly with the Research Triangle Institute of Durham, N.C., has joined the staff of the Navy's Operations Evaluation Group as director of its newly established Applied Science Division at the Massachusetts Institute of Technology.

Charles W. Mushett has been appointed director of scientific relations of the Merck Sharp and Dohme Research Laboratories Division of Merck and Co., Inc., replacing **Hans Molitor**, who has retired. Mushett has been

working in the department of scientific relations since early in 1957. The department is responsible for maintaining contacts with scientists and scientific developments outside the company, both in the United States and abroad.

Bernard Frank is now associated with Colorado State University as professor of watershed management. He previously spent a year in India on an FAO mission to initiate watershed-management research in that country through the central government's Forest Research Institute.

Kollsman Instrument Corporation, Elmhurst, N.Y., has announced the formation of a research division and the appointment of **Arthur S. Robinson** as director of research. The new organization will undertake basic and applied research related to advanced tracking, computing, communications, control, instrumentation, and display systems. Formerly, Robinson directed the Advanced Electronics Laboratory at the Bendix Eclipse–Pioneer Division.

Leo L. Laythe, regional director of the Bureau of Sport Fisheries and Wildlife's Pacific Region, with headquarters at Portland, Ore., will retire on 31 December after 42 years of government service. He will be succeeded by **Paul T. Quick,** chief of the bureau's Division of Wildlife in Washington, D.C.

Laythe has been regional director of the Pacific Region, comprising the states of Washington, Oregon, California, Nevada, Idaho, Montana, and Hawaii, since 1940. In 1949 he organized the Columbia River Fisheries Development Program to preserve the important salmon runs from destruction by the building of dams. He coordinated federal and state efforts in the construction of fish hatcheries and the installation of fish passage and fish protection facilities at major hydroelectric dams and irrigation systems. In 1958 he was commended by the Assistant Secretary of the Interior for Fish and Wildlife for his work in developing the migratory bird feeding program in California.

Robert T. Nieset, director of the biophysics laboratory and professor of physics at Tulane University, has been appointed chairman of the department of physics in the College of Arts and Sciences at Tulane. He succeeds **Joseph C. Morris**, who resigned to give major attention to his duties as vice-president of the university.

Kenneth H. Drummond, formerly assistant director of the Smithsonian Institution's Astrophysical Observatory, has been appointed assistant to chief campus officer Roger Revelle of the University of California, La Jolla. Drummond will be responsible for all general nonacademic departments on the La Jolla campus, which include the School of Science and Engineering and the Scripps Institution of Oceanography.

New chairman of the chemical engineering department in the Northwestern University Technological Institute is **George Thodos**, professor of chemical engineering and an institute faculty member since 1947. He is a specialist in petroleum technology.

Herman Skolnik, manager of the technical information division of Hercules Powder Company, Wilmington, Del., has been named editor of a new American Chemical Society publication, the *Journal of Chemical Documentation*, to be published twice a year beginning in 1961.

Robert B. Arnold, associate professor of physics at the United States Military Academy at West Point, has been appointed to the staff of the publications department of the American Institute of Physics. He will assume his new duties upon retirement from the Army.

Recent Deaths

C. Barton Addie, Philadelphia, Pa.; 79; emeritus professor of orthodontics at Temple University and former acting dean of the School of Dentistry; 1 Nov.

Charles G. Darlington, Plainfield, N.J.; 68; professor of pathology at New York University's College of Dentistry and director of the Undergraduate Cancer Teaching Program; taught at the university for 43 years, and until last year was chairman of the pathology department; was a founding fellow of the College of American Pathologists and a diplomate of the American Board of Pathology; 5 Nov.

Ralph Falk, Chicago, Ill.; 74; board chairman of Baxter Laboratories, Inc., and a pioneer in the development of intravenous feeding; president of Baxter from its organization in 1931 until he became chairman 7 years ago; 2 Nov.

Charles H. Forsyth, Hanover, N.H.; 75; professor emeritus of mathematics at Dartmouth College; specialist in the mathematics of finance, insurance, and business statistics; author of four books and about 60 articles; taught at Dartmouth for 35 years before his retirement in 1951; 2 Nov.

Sir **Harold Spencer Jones**, London, England; 70; Astronomer Royal, in charge of the Royal Observatory, from 1933 to 1955; secretary general of the International Council of Scientific Unions since 1956; led a 12-year international project, concluded in 1942, to measure the sun's distance from the earth; books include *A Picture of the Universe* (1947) and *Worlds Without End* (1935); served as president of the British Astronomical Association, the British Horological Institute, and the International Astronomical Union, and was the recipient of a great many foreign honors, including the 1955 medal of the Rittenhouse Astronomical Society of Philadelphia; 4 Nov.

Peter O. Okkelberg, Ann Arbor, Mich.; 79; professor emeritus of zoology and associate dean emeritus of the graduate school, University of Michigan, where he had been a faculty member for 50 years; anatomist, embryologist, and cytologist, specializing in germ-cell history in vertebrates; divisional editor of *Biological Abstracts* for 33 years; 13 Sept.

Harry J. Reed, Lafayette, Ind.; 73; former dean of agriculture at Purdue University; since retiring 3 years ago had traveled between Lafayette and Washington as coordinator of a federal-state rural development program; led the United States wheat mission to Pakistan in 1953 and the agricultural trade mission to Latin America in 1954; received the Distinguished Service Award of the American Farm Bureau in 1955; 5 Nov.

Mildred W. S. Schramm, Bloomington, Ind.; 71; as secretary of the International Cancer Research Foundation from its organization in 1932 until 1948, administered research grants, inaugurated postdoctoral research fellowships, helped found the journal *Cancer Research*, organized international conferences on specialized research topics, and established cancer prevention clinics in the teaching hospitals of Philadelphia; from 1948 to 1950, as director of the Division of Cancer Control of the North Carolina State Board of Health, established a state-wide system of cancer clinics; 5 Oct.

Will M. Winton, Fort Worth, Texas; 75; chairman of the department of biology and geology at Texas Christian University, 1913–57; 9 July.

Reports

n-Tridecane and trans-2-Heptenal in Scent Gland of the Rice Stink Bug Oebalus pugnax (F.)

Abstract. The scent-gland secretion of the rice stink bug *Oebalus pugnax* (F.) is composed of a liquid two-phase system. The saturated hydrocarbon *n*-tridecane accounts for 60 percent of the secretion. In the other phase, the major organoleptic compound is the *trans* form of 2-heptenal.

A major characteristic of members of the family Pentatomidae is their ability to eject compounds of considerable pungency. Because of this trait they are described appropriately as stink bugs. It is believed that the odoriferous substances ejected by the pentatomids are protective against potential predators (*1*).

The large, round, reddish-orange scent gland is situated on the floor of the body cavity, extending through the metathoracic and first abdominal segments and into the second abdominal segment. The gland is highly developed in both adult males and females but is poorly developed in the nymphs, which do not produce the odoriferous substances. The scent-gland secretion of *Oebalus* is ejected through a pair of small ducts opening onto each side of the metathorax through an ostiole.

The odoriferous secretion was collected by piercing scent glands with fine capillaries. The secretion consists of orange-yellow droplets which are suspended in a clear liquid. The clear liquid phase has been identified as *n*-tridecane, and in the orange-yellow liquid phase one of the main organoleptic compounds has been identified as *trans*-2-heptenal.

Infrared examinations (*2*) were made from a film of the secretion. The following diagnostic bands were present: aldehyde C—H, 3.66 μ; C=O, 5.89 μ; C=C, 6.08 μ; *trans* C=C, 10.25 μ. The C—H/C=O ratio further indicated that a high concentration of a hydrocarbon was present in the mixture.

The scent-gland secretion was analyzed by injection of 1-μl samples into the inlet of a Perkin-Elmer model 154B vapor phase chromatograph; tris-phenoxyphenyl-*n*-dodecyl silane was used as an absorbent. The operating temperature was 160°C, with a helium flow rate of 50 cm^3/min. Three main components were detected. Two were low-boiling and were collected along with several minor components by condensing them in microtubes immersed in liquid nitrogen as they issued from the outlet of the instrument. This fraction was orange and had the typical odor associated with *Oebalus*.

The third major component accounted for 60 percent of the total sample. It was isolated in the same manner as the organoleptic fraction. This component was a clear, odorless liquid which boiled at 233°C and melted at −6.1°C. Infrared examination demonstrated that this material was a saturated hydrocarbon, and elemental analysis established an empirical formula of $C_{13}H_{28}$ (C, 84.91 percent; H, 15.06 percent). These data are all in agreement for *n*-tridecane. The linearity of the compound was demonstrated by its ability to form a urea addition compound (*3*). Confirmation was further established by analysis on a modified Consolidated 21-102 analytic mass spectrometer. The fragmentation pattern was identical with that of a sample on pure *n*-tridecane (Table 1).

The aldehyde-rich organoleptic fraction was dissolved in absolute ethanol and was added to a saturated solution of 2,4-dinitrophenylhydrazine in 2*N* HCl. The resulting 2,4-dinitrophenylhydrazones were separated by filtration and rinsed with boiling ethanol. A portion of the 2, 4-dinitrophenylhydrazone mixture was alcohol-insoluble and was characterized as a dicarbonyl compound. The alcohol-soluble derivatives were chromatographed by the method of Gordon *et al.* (*4*). One major component was isolated; its melting point was 130 to 131°C. The empirical formula of this compound corresponded to a heptenal. (Calculated for $C_{13}H_{16}N_4O_4$: C, 53.42; H, 5.48; N, 19.18 percent. Found: C, 53.61; H, 5.40; N, 19.30 percent.) A melting point in admixture with an authentic sample of the derivative of 2-heptenal produced no melting point depression. The infrared spectrum of the *Oebalus* derivative was identical with that of the corresponding derivative of 2-heptenal. The presence of this enal in the scent-gland secretion was further demonstrated by the facts that the mass spectrometric fragmentation pattern of the organoleptic layer contained a maximum heptenal parent mass of 112 and that the resulting fragmentation pattern contained peak masses identical with those of synthetic 2-heptenal. The grassy odor of this aldehyde is very similar to that of the secretion of *Oebalus*.

Neither *n*-tridecane nor 2-heptenal has been isolated previously from any members of the animal kingdom. However, the grease layer extracted from the cuticle of the cockroach *(Periplaneta)* has been shown to contain a series of aliphatic hydrocarbons in the range C_8 to C_{12} (*5*). *n*-Tridecane occurs in brown coal tar (*6*) and cracked shale tar kerosene (*7*). 2-Heptenal is one of the carbonyls associated with the odor of cooked chicken (*8*) and also occurs in reverted soybean oil (*9*), oxidized skim milk (*10*), and rancid pork (*11*). This enal is closely related to the carbonyl 2-hexenal isolated from the roach *Eurycotis floridana* (Walker) (*12*).

Oebalus pugnax ejects its scent-gland secretion in large droplets. The ejected

Table 1. Mass spectrometric analysis of the *Oebalus* hydrocarbon.

e/*M**	Actual division of spectrum	*n*-Tridecane	Residual
41	3911.0	3910.4	+0.6
42	1030.2	1030.3	−0.1
43	6570.8	6570.8	0
44	210.4	210.3	+0.1
55	1330.0	1330.6	−0.6
56	1086.3	1086.1	+0.2
57	5810.6	5810.3	+0.3
70	839.0	838.4	+0.6
71	2960.1	2960.7	−0.6
72	145.7	145.8	−0.1
84	405.0	405.0	0
85	1821.0	1820.6	+0.4
86	105.6	105.5	+0.1
98	289.1	288.5	+0.6
99	290.3	290.2	+0.1
112	136.9	136.4	+0.5
113	153.4	153.8	−0.4
126	85.4	85.5	−0.1
127	127.8	127.2	+0.6
141	84.1	84.0	+0.1
155	49.5	49.5	0
169	1.7	1.5	+0.2
184	212.0†	212.3†	−0.3

* Charge/mass. † Parent mass.

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

carbonyl compounds are easily detected as orange spots when the bugs are placed on filter papers saturated with 2,4-dinitrophenylhydrazine. The ejection can be either bilateral or unilateral. Unilateral ejection was most commonly observed when the bugs were approached by imported fire ant workers (*Solenopsis saevissima* v. *richteri* Forel). Ants which were exposed to the spray rapidly moved away. This would seem to support the belief that the odoriferous secretions of the pentatomids are at least partially protective.

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17 June 1960

Use of Cytoplasmic Male-Sterility in Making Interspecific Crosses in Allium

Abstract. Cytoplasmic male-sterile plants of *Allium cepa* were used in making interspecific crosses with *A. fistulosum*. Some inbred lines of *A. cepa* produce more seed than others. Other *Allium* species could also be used as the pollen parent.

In plant breeding hand emasculation is often slow and painstaking; the results are somewhat disappointing and the number of F_1 progeny is limited. The cytoplasmic male-sterile character in *Allium cepa* L., as reported by Jones and Clarke (*1*), is extremely useful in crossing *A. cepa* and *A. fistulosum* L.

Eight cytoplasmic male-sterile inbred lines of *A. cepa*, each represented by 10 mother bulbs, were placed in an insect-proof isolation cage 3½ by 6 by 6 feet. Though *A. cepa* bloomed much later than *A. fistulosum*, no particular difficulty was encountered. By growing several thousand *A. fistulosum* plants, a sufficient number of late-flowering umbels were obtained. The seedstalks, with stems as long as possible, were cut and placed in a container of water to which 1 part of copper per million in the form of copper sulfate was added to prevent growth of fungi and algae. The container of flowers of *A. fistulosum* was then placed in the cage with the *A. cepa* inbred lines. Honey bees (approximately 3 pounds of workers with a queen, brood, comb, and so forth) were used as the pollinators.

The inbred lines used and the number of seeds from each inbred line are given in Table 1. Of course, the difference in bloom time could account for some but probably not all of the difference noted. I feel that some inbred lines will cross more readily with *A. fistulosum*, although sufficient data are not available for a definite statement. The well-known constancy of bees in pollinating a particular species, strain, or even individual plant, or their preference for plants with high sugar levels in the nectar as reviewed by Grant (*2*) was not a factor in the pollination of the material in this report. The bees were confined to a small volume and were not free to forage. Food was not too plentiful within the cage. The bees visited each and every plant without preference for one or the other. Some of the F_1 progeny were male-fertile, others male-sterile. Ratios were not determined.

The characteristics of *A. fistulosum* are sufficiently distinct from those of *A. cepa* that the two species are readily identified. The hybrid between the two species is intermediate in character. Plants grown from the seeds reported in Table 1 were hybrids between the two species. Emsweller and Jones (*3*) have described the interspecific hybrid.

This system of crossing eliminates emasculation, reduces possible contamination, increases the chance of a cross, and produces a greater number of seeds. When single umbels are being crossed, houseflies or blue-green bottle flies can be used as pollinators. A male-sterile umbel of *A. cepa* can be enclosed in a small cage with the male-fertile umbel of *A. fistulosum*.

Though only a few seeds were produced, they were adequate to grow out the F_1 generation. The F_1 interspecific hybrids produced in the foregoing manner may be either male-fertile or male-sterile. Male-fertile plants may be used as the pollen parents in a backcrossing program with male-sterile *A. cepa* as the recurrent female parent. Male-sterile F_1 interspecific hybrids can be used as the female parent with a male-fertile *A. cepa* as the pollen parent.

Table 1. Number of seeds produced on eight male-sterile *A. cepa* inbred lines pollinated by *A. fistulosum* with honey bees in an insect-proof isolation cage, Parma, Idaho, 1955.

Inbred source	Pedigree	No. of seeds
Early yellow globe	B 2108 A	30
Early yellow globe	B 2117 A	40
Brigham yellow globe	B 2190 A	200
Brigham yellow globe	B 2207 A	75
Brigham yellow globe	B 2217 A	30
Brigham yellow globe	B 2218 A	55
Brigham yellow globe	B 2267 A	40
Yellow sweet Spanish	B 12132 A	20

Although only *A. cepa* was crossed to *A. fistulosum* by this method, other *Allium* species could be used as the pollen parent. The system is simple and effective in making interspecific as well as intraspecific crosses in the *Allium* species, in which a male-sterile *A. cepa* can be used as the seed parent (*4*).

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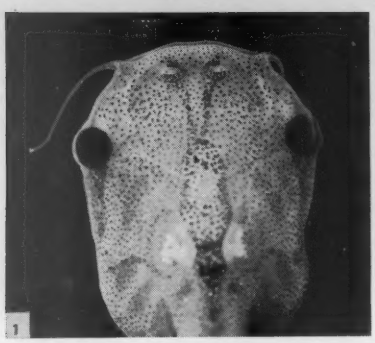
24 August 1960

Pineal Regulation of the Body Lightening Reaction in Amphibian Larvae

Abstract. Body pallor due to contraction of both deep and integumental melanophores occurs when either blinded or normal *Xenopus laevis* and other amphibian larvae are placed in the dark. The reaction is abolished by pinealectomy, but is induced by administration of pineal hormones. It is suggested that the normal body lightening reaction is mediated by the pineal gland.

It has been known for many years that due to melanophore contraction amphibian larvae become pale when subjected to darkness for periods of a few hours (*1–3*). The mechanism of this lightening reaction, however, remains unexplained and our understanding of it has been further complicated by observation that the phenomenon is not abolished in blinded larvae (*2*). With this in mind and as a result of the discovery that the tail darkening reaction of *Xenopus laevis* is due to a direct effect of light on tail melanophores (*4*), it was suggested that a similar photochemical mechanism might mediate the body lightening reaction (*3*). In the course



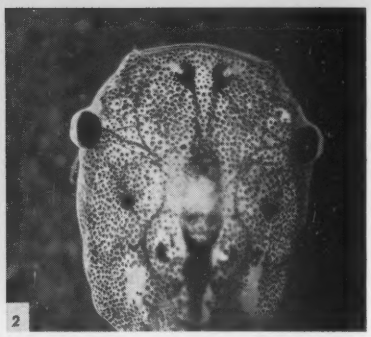


Fig. 1 (left). Normal *Xenopus* larva at the height of body lightening after 60 minutes in the dark. Note the extreme contraction of melanophores in the skin and on blood vessels and nerves. The paired thymus glands which are usually quite obvious because of their heavy pigmentation can hardly be seen. Fig. 2 (right). Pinealectomized *Xenopus* larva after 60 minutes in the dark. No melanophore contraction has occurred and as a result the thymus glands, optic nerves and various blood vessels are clearly discernible. Scar indicates site of cautery.

of an investigation of this possibility, an alternative hypothesis involving the pineal gland was developed because of the well-known visual associations of the pineal complex (*5*) and the frequently reported melanophore contracting activity of pineal extracts (*6*). In the investigation described in this report, both of these hypotheses were evaluated experimentally, and a mechanism is proposed to explain the normal regulation of the body lightening reaction.

When normal or recently blinded *Xenopus* larvae are placed in the dark, melanophore contraction begins in about 15 minutes, at normal laboratory temperatures (about 23°C), and maximum pallor occurs (Fig. 1) in approximately 30 minutes. After the animals are returned to normal illumination, re-expansion of body melanophores of these lightened tadpoles proceeds slowly, requiring 45 to 60 minutes for the restoration of normal pigmentation. Similar temporal factors are observed in the body lightening reaction displayed by larvae of several other amphibians, including various species of *Rana* and *Ambystoma*.

The time intervals involved in these data strongly refute the possibility of a photochemical effector for body lightening; for if such a system is involved, as it is in the tail melanophores of *Xenopus*, one should expect body lightening to occur relatively slowly during the interval in the dark and to disappear very soon after larvae are returned to light. Further evidence against the possibility that body melanophores are directly sensitive to changes in illumination is derived from a series of experiments done in vitro. The results of these experiments indicate that melanophore contraction does not occur in the skins of the dorsal surface of *Xenopus* larvae which are maintained in various physiological salt solutions and subjected to periods of darkness. That these melanophores retain physiological activity is demonstrated by their response to various melanocyte-stimulating hormone preparations (*7*) added to the medium.

The time factors involved during the onset and termination of the body lightening reaction suggest that small amounts of a "hormone" might be released when tadpoles are placed in the dark and that release of this "hormone" ceases when they are returned to the light. This would explain why the reaction starts as quickly as it does. It seems logical to assume that during the subsequent 45 minutes required for redarkening, normal metabolic processes reduce the amount of "hormone" to an ineffective level. At this point one of our unpublished experiments was recalled in which larvae of *Ambystoma opacum*, *Rana pipiens*, and *Xenopus laevis* were immersed in dilute solutions of melatonin (N-acetyl-5-methoxytryptamine), a potent, direct acting, melanophore contracting compound isolated by Lerner (*8*) from the pineal glands of cattle. Body lightening induced in larvae by this compound is identical to that which is seen when tadpoles are placed in the dark (Fig. 1). Deep melanophores on blood vessels, nerves, and various organs, as well as those in the integument, contract markedly. Furthermore, melatonin at a concentration of 0.01 mg/ml of aquarium water elicits body lightening, but does not inhibit the tail darkening reaction. This response seems identical to that which occurs when *Xenopus* larvae are placed in the dark. Higher concentrations of melatonin completely abolish tail darkening (*9*).

Altogether, these observations seemed to implicate the pineal gland, and as a result the body lightening reaction was investigated in over 25 *Xenopus* larvae, at various stages, which had been deprived of their pineal glands. "Pinealectomy" was performed by cauterizing the pineal area of the diencephalic roof with either a hot needle or a cold cautery apparatus. Larvae with cauterized parts of the optic tectum or olfactory lobes served as sham-operated controls. Blinded, sham-operated, or normal larvae displayed typical body lightening when placed in the dark. Pinealectomized larvae consistently displayed no melanophore contraction under these conditions (Fig. 2), and their tails were even darker than those of the control groups.

On the basis of all the data presented in this report, it is proposed that the following mechanism operates in the normal regulation of the body lightening reaction observed in the larvae of many amphibian species. When larvae are placed in the dark, the lack of either sufficient quantities or appropriate wavelengths of light almost immediately stimulates the pineal gland to secrete small amounts of melatonin or a similar substance. This compound, which is active at very low concentrations (*10*), overrides melanophore expansion induced by hypophyseal chromatotrophic hormone and causes body melanophores to contract, giving rise to the body lightening reaction. When larvae are returned to normal illumination, the pineal is affected and it ceases to release melatonin. Gradually, normal metabolic processes reduce the quantity of circulating hormone to a level below that necessary for melanophore contraction. Subsequently, redarkening occurs. The fact that the latter requires only about 45 minutes, together with the observation that tail darkening is hardly affected, indicates that only small quantities of melatonin are released during the occurrence of the normal body lightening reaction.

The mechanism proposed in this report represents an integration of two events, light reception and melanophore contraction. Both of these have often been implicated in studies of pineal complex, but to my knowledge the present investigation is one of the few demonstrations of their association in normal melanophore reactions (*11*).

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27 June 1960

Experimental Study of Teratogenic Effect of Emotional Stress in Rats

Abstract. The teratogenic effect of audio-visual and immobilization stress was studied in rats. Groups of 15 animals were subjected from the 9th to the 12th day of pregnancy to one or the other of these types of stress or to stress combined with administration of vitamin A. It was shown that the stresses alone had no effect on congenital malformations. Immobilization stress seemed to potentiate the teratogenic effect of vitamin A.

Rats of the Holtzman strain, ranging in weight from 250 to 320 g, were used in the experiment reported here (*1*). The female animals were kept together with males. Vaginal smears were taken every night and examined for spermatozoa. The day on which spermatozoa were found was regarded as the first day of pregnancy. The pregnant rats were divided at random into six groups with 15 animals in each group. The groups were treated as follows. Group 1 consisted of control animals. Rats in group 2 were subjected to intermittent ringing of bells and flashing of light (*2*) from the 9th to the 12th day of pregnancy for 6 hours daily. Rats in group 3 were subjected to immobilization, as described by Renaud (*3*), for 3 hours on the 9th day and for 4 hours from the 10th to the 12th day of pregnancy. Each rat in group 4 received, by intubation, 15,000 international units of vitamin A in oily suspension (*4*) daily from the 8th to the 12th day of pregnancy. Rats in group 5 were also given the vitamin A and, in addition, were subjected to audio-visual stress, like those in group 2. Rats in group 6 received the vitamin A and, in addition, were subjected to immobilization, like those in group 3.

All animals were allowed to eat Purina laboratory chow ad libitum and were also fed raw potatoes and dry bread three times a week. The animals were killed on the 20th day of pregnancy. The young were removed, weighed, and preserved in 10-percent Formalin until they had been examined macroscopically. Deformities of the brain and calvaria as well as cleft palate were recorded.

The results are shown in Table 1. No congenital malformations were found in young of the control group or of the groups which were subjected to stress only (groups 2 and 3). In the group fed vitamin A but not subjected to stress (group 4) there was a low incidence of malformations; these were confined to about one-third of the litters. About the same proportion of malformations occurred in the group in which feeding of vitamin A was accompanied by audio-visual stress (group 5). In the young of rats that had been fed vitamin A and had also been immobilized (group 6), the percentage of cleft palates was eight times as high as in the young of those that had only been given the vitamin, and the percentage of young with some malformation was about five times as high. The percentage of resorbed embryos in group 6 was relatively high—a fact which explains the lower number of young per litter in the group. This may also explain the small number of young with deformities of brain and calvaria in this group, since it is known that embryos with severe malformations tend to die and are then resorbed.

Animal experiments have shown that administration of cortisone during pregnancy increases the teratogenic effect of vitamin A hypervitaminosis in rats (*5*). Cortisone has also been found to increase the incidence of cleft palate in mice of a genetic strain in which there is normally a low incidence of cleft palate (*6*). Since stimuli causing nervous excitement are known to increase adrenal cortical secretion (*7*), a similar, teratogenic effect might be expected as a result of emotional stress.

Although the audio-visual stress had some effect on the behavior of the animals in our experiment, causing them to hide under each other and to wash their faces (*8*), it did not increase the frequency of vitamin-A induced deformities. Possibly it was not severe enough. Immobilization is a severe stress in rats; it causes a typical alarm reaction, with enlargement of the adrenals within a few hours (*3, 9*). Its severity, even if applied for 3 to 4 hours on 4 days only, is shown by the fact that a vaginal bleeding with coagula was observed in four animals during immobilization. The bleeding appeared on the 11th or 12th day of pregnancy and almost certainly was a sign of abortion. It differed radically from the small physiological uterine bleeding which is a characteristic sign of pregnancy in rats and appears usually on the 14th day of pregnancy (*10*). Since the uteri of the animals with observed bleeding looked like the uteri of the other nonpregnant animals, it is quite probable that immobilization had caused a miscarriage in most of the nonpregnant animals of groups 3 and 6.

Immobilization alone did not cause any malformations, but it seemed to increase the teratogenic effects of vitamin A. This result is similar to the findings of Millen and Woollam (*5*), that cortisone administration increases the teratogenic effect of vitamin A hypervitaminosis in rats but does not itself cause malformations. Immobilization has been called a pure emotional stimulus (*3, 9*), but this can be argued, of course, and the same authors have also called it a "neuromuscular exer-

Table 1. Effect on congenital malformations in the offspring of rats of audio-visual stress, immobilization stress, and vitamin A plus stress. Figures in parentheses, percentages of total.

Item	Controls	Stress		Vitamin A	Vitamin A plus stress	
		Audio-visual	Immobilization		Audio-visual	Immobilization
Rats with spermatozoa in vaginal smear (No.)	15	15	15	15	15	15
Mean weight of rats on 1st day of pregnancy ± standard error (g)	266.3 ±6.25	269.0 ±8.51	262.3 ±6.87	272.3 ±6.75	271.2 ±6.12	270.7 ±4.76
Rats with young (No.)	14	13	8	14	14	5
Rats with vaginal bleeding (observed abortions) (No.)			2			2
Totally resorbed embryos (No.)		7	3	2	1	9
Young (total No.)	182	152	102	178	162	49
Mean weight of young (g)	2.40	2.47	2.45	2.46	2.65	2.41
Young per litter (No.)	13.0	11.7	12.8	12.7	11.6	9.4
Litters with deformities (No.)				5	5	3
Young with deformities (total No.)				13 (7.3)	7 (4.3)	18 (36.7)
Young with deformities of brain and calvaria (No.)				11 (6.2)	3 (1.9)	1 (2)
Young with cleft palate (No.)				8 (4.5)	4 (2.5)	18 (36.7)

tion" (*11*). The struggling of properly immobilized animals was minimal after the first day, and lesions or tourniquet effects in the extremities were avoided through adequate technique. If this particular form of stress is regarded as mainly emotional, the results support the opinion that emotional factors may under certain circumstances favor the manifestation of congenital defects (*12*).

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12. We wish to thank Dr. Ancel Keys for giving us the opportunity to carry out this study during our stay in the United States.

2 June 1960

Perturbations of the Orbit of the Echo Balloon

Abstract. The motion of the Project Echo communications satellite during its first 12 days clearly confirms previous predictions of the influence of solar radiation pressure. During this time, solar pressure reduced perigee height by 44 km. The approximate value of 1.1×10^{-13} g/cm^3 has been obtained for the average air density at the 1600-km altitude of the satellite.

The successful launching of the Echo I balloon on 12 August 1960 provided the first definitive test of the effect of solar radiation pressure on satellite orbits. The importance of this effect on the orbits of large, lightweight satellites was originally discovered and first demonstrated theoretically in the spring of 1959 by the authors, in collaboration with R. W. Parkinson (*1*).

As reported by the National Aeronautics and Space Administration (NASA), Echo I is an aluminum-coated, half-mil Mylar sphere, 100± 1 feet in diameter. Its weight when launched was 157.00 lb, including 33.34 lb of sublimating powders. Hence its cross-sectional area-to-mass ratio (A/M) was initially 102 cm^2/g. Small holes introduced before launching, and meteoric punctures, will permit gas to escape, reducing the mass at a rate difficult to predict. The acceleration due to solar radiation is $K(I/c)(A/M)$, where I is the solar energy flux (*2*), c is the velocity of light, and K is a constant ($0 \leqq K \leqq 2$) whose value depends on the reflecting characteristics of the surface. For specular reflection from a perfect sphere, $K = 1$. Small irregularities in the shape or any diffuseness in the reflection of sunlight will tend to increase K. (For a sphere whose reflection is completely diffuse, $K = 1.44$.) In addition, if the balloon surface nearest the sun is at a higher temperature, the emitted infrared radiation will be nonisotropic and will have the effect of increasing K.

At the time of writing of this report, orbit data were available only for the first 12 days. Orbital elements were computed from the data by P. Zadunaisky of the Smithsonian Astrophysical Observatory (*3*, *4*). Zadunaisky used only unrefined angular data obtained by the Baker-Nunn cameras. Each computed set of elements was determined from two days of observations, centered about the epoch of the elements. The trial expressions for the mean anomaly, the eccentricity, and the argument of perigee consisted of second order polynomials. However, in the latter two cases, all but the lowest order coefficient were held fixed throughout the computation (*5*). The data obtained each day were well distributed about the orbit, and hence the residuals are rather small; the probable errors of the elements are indicated on the appropriate graphs (see Figs. 1 and 2). Short-period terms appear neither in the elements computed from observations nor in our theoretical results, since these terms are averaged out in both cases.

In Fig. 1, we have plotted the orbit eccentricity (e) versus time through

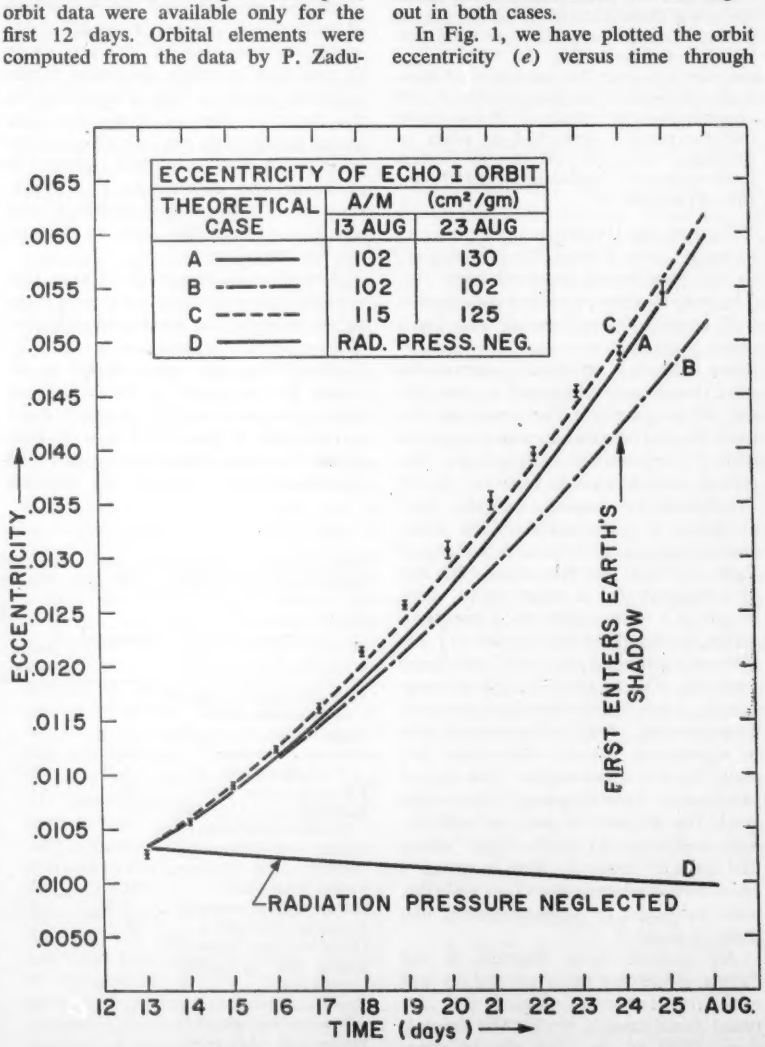

Fig. 1. Time variation of eccentricity.

25 August. It can be seen that the initial increase in eccentricity was about 3×10^{-4} per day, and that this rate increased to about 5.5×10^{-4} per day in 12 days. Similarly the argument of perigee (ω), plotted in Fig. 2, shows a varying rate of increase. The other three elements [semimajor axis (a), longitude of ascending node (Ω), and inclination (i)] are not plotted, because over this short time interval the effects of radiation pressure on these elements are comparable to the probable errors associated with the data. Gravitational and air drag perturbations adequately account for the observed changes in these elements.

The theoretical cases A, B, C, and D, also plotted on Figs. 1 and 2, all include the effects of air drag and gravitational perturbations. Case D omits the effect of radiation pressure entirely. Note that without radiation pressure e would decrease initially instead of increase, mostly because of the third harmonic of the earth's field, but also because of air drag. The linear increase in ω in case D is due primarily to the second harmonic. The wide divergence between case D and the experimental points on both figures shows that an important perturbation has been neglected.

Cases A, B, and C include the effects of radiation pressure, but make different assumptions about the "effective" area-to-mass ratio, KA/M. In case B, we assume KA/M has the constant value 102 cm²/g. This could correspond to complete specular reflection from a spherical Echo balloon which maintains its initial mass. However, this model cannot account for the experimental change in e, regardless of choice of initial orbital elements. Case A assumes an initial KA/M of 102 cm²/g; but this value was increased by about 2 percent per day (6) until 23 August, and was then kept constant at 130 cm²/g. Such an increase could, for example, correspond to a loss, from the Echo balloon (with $K = 1$), of 3.2 lb of sublimated powder each day for 10 days. It is clear that Case A results in a closer fit to the eccentricity data, without substantially changing the variations in ω.

Better agreement with the data can be obtained by increasing the initial value of KA/M (7). For example, case C assumed an initial value of 115 cm²/g whose reciprocal was increased by 7×10^{-5} g/cm² per day. One possible realization of this model would be an Echo balloon (with $K = 1.13$) that loses mass at the rate of about 1 lb per day.

In Fig. 2, we find that the slope of the experimental data and of curves for cases A, B, and C are initially quite different from that of case D. However, after the first week, the slopes all approach the same value. This fact is easily explained: As the earth-sun line approaches perpendicularity with the line of apsides, radiation pressure tends to displace the orbit in the direction of the latter line, and therefore its effect on the argument of perigee diminishes. On 24 August the earth-sun line is perpendicular to the line of apsides, and the change in ω due to the solar pressure vanishes, leaving only changes due to the other perturbations (which are common to all four cases).

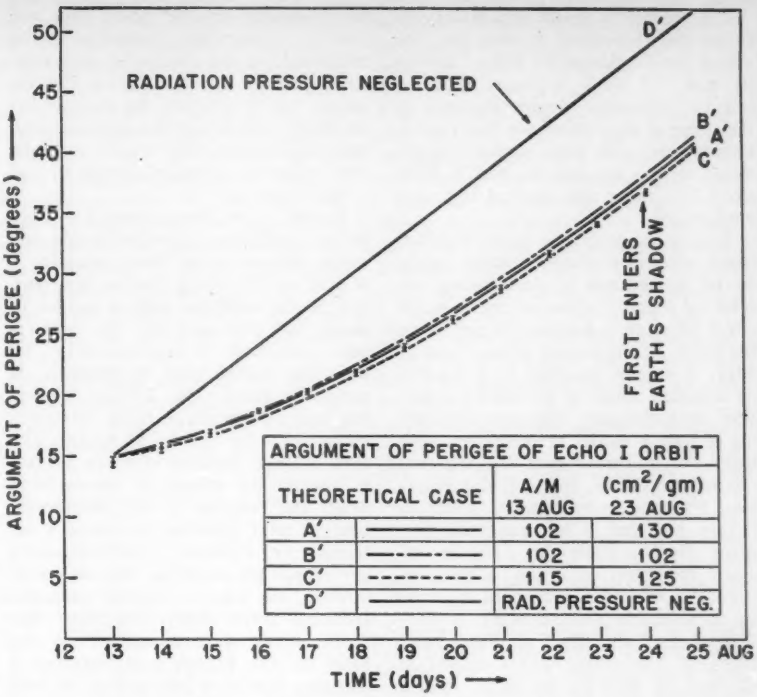

Fig. 2. Time variation of argument of perigee.

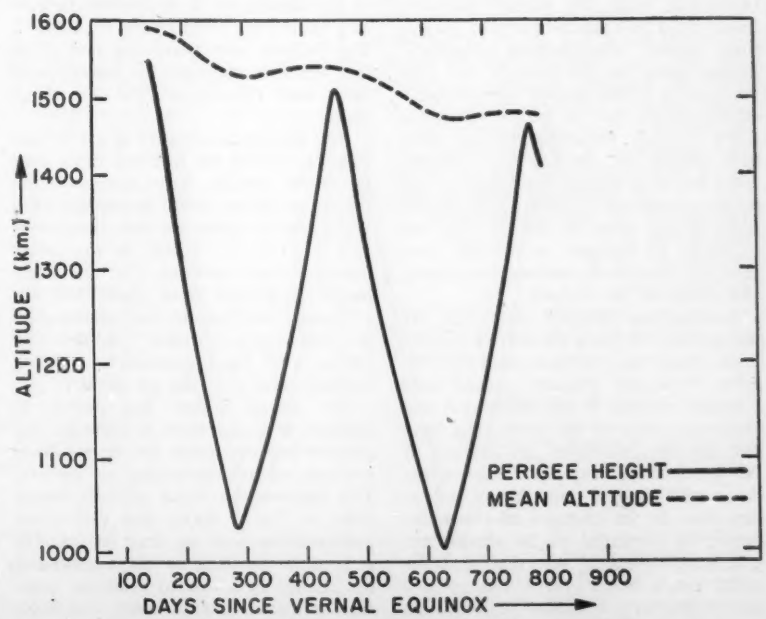

Fig. 3. Time variation of perigee height and mean altitude.

The generally good agreement between the theoretical models and the actual orbit followed by Echo I during its first 12 days indicates that no drastic, permanent change occurred in the shape of the balloon for that period. Polarization and cross section experiments carried out with the M.I.T. Millstone Hill radar also support this conclusion (*8*).

In our analysis we have included many other perturbations which might be of importance in determining the orbit of Echo I. One of these is the effect of solar radiation reflected from the earth. At the present state of knowledge, it is not possible to formulate an accurate model of the earth's reflection characteristics. We are considering a simple model involving an arbitrary but uniform (over the surface) mixture of diffuse and specular reflection. However, only specular reflection is now included in our computer program. Results from this program indicate the effect on e and ω, even assuming a reflection coefficient of unity (a considerable overestimate), is only 1 percent of the effect of direct solar pressure. The perturbations caused in the first 12 days by the third, fourth, and fifth harmonics of the earth's gravitational field, and by the lunar and solar fields, are mostly quite small. (One exception is the change in eccentricity, caused by the third harmonic, which is $\sim -3 \times 10^{-5}$ per day).

The effect on the orbit of a possible charge on the balloon was also investigated. Calculations indicate that even if the potential of the balloon were 100 volts the effect on the orbit due to interaction with the earth's magnetic field would be several orders of magnitude below observational accuracy. Charge drag at this altitude can also be ignored. Other known perturbations which cannot yet be treated quantitatively include variations in the solar flux; effects of corpuscular radiation from the sun; momentum transfer due to micrometeorite impacts; and fluctuations in the value of KA/M due, for example, to changes in thermal conductivity, spin rate, surface conditions, and shape of the balloon.

Calculations indicate that since the balloon did not enter the earth's shadow until about the 140th revolution (*9*), direct radiation pressure caused only a minute change in the inclination and ascending node of the orbit—less than 10^{-4} deg/rev. However, an analysis of the perturbation equations shows that the earth's shadow can play an important part in the changes of these elements. In particular, if the shadow region is asymmetrical with respect to the nodal line, a much greater change in Ω occurs. Similarly, a shadow region which is asymmetrical with respect to the perpendicular to the nodal line will lead to a noticeable change in i. The magnitude of the change is, of course, dependent on many variables. For example, on 29 August, the shadow lies wholly on one side of this perpendicular and extends about 80° in true anomaly. This results in a rate of change in i of −.003° per day.

In Fig. 3, we have plotted the theoretical prediction of perigee height and mean altitude versus time, assuming a KA/M of 102 cm²/g. We see that perigee height oscillates with a period of about 300 days and that the peak-to-peak amplitude is approximately 500 km. The initial rate of decrease of perigee height is about 2.0 km/day; but this rate then increases to its maximum value of 5.3 km/day by 29 August. The slow average decrease in mean altitude is due to the effects of atmospheric drag. The decrease is not monotonic, because solar radiation can cause a net increase (or decrease) in orbital energy per revolution when the balloon passes through the earth's shadow (nonconservative force field). We note that these curves were computed on the basis of the balloon's maintaining a constant $KA/M = 102$ cm²/g. As was indicated above, KA/M is larger for the Echo balloon; this will cause a proportionate increase in the peak-to-peak amplitude of the oscillation in perigee height, but it will have no effect on the period. Since KA/M can be expected to change radically if the balloon loses its spherical shape, large deviations from these curves may be expected. In view of the uncertainties involved and our imprecise knowledge of air density, it is impossible to predict accurately the lifetime of Echo I. The balloon may perish on one of its first descents through the atmosphere, or it may remain in orbit for many years.

The average air density at a 1600-km altitude, during the first five days after the Echo launch, was obtained from the decay of the orbit's semimajor axis. We found a value for this density of $(1.1 \pm .2) \times 10^{-15}$ g/cm³. In the calculation, it was assumed that the scale height is greater than about 130 km (*10*), and that the air drag acceleration is $(A/M)v^2\rho$, where $A/M = 102$ cm²/g, v is the instantaneous satellite velocity, and ρ is the air density.

For orbits which are partly in shadow, it is necessary to consider the gain or loss of energy due to radiation pressure when determining air density. The increases in mean altitude versus time in Fig. 3 show that this effect predominates over air drag for months at a time. In fact, at these altitudes, the change in a due to radiation pressure is almost always more important than the change due to air drag—provided that the orbit is partly in shadow.

We also note that the minimum perigee heights shown in Fig. 3 always occur on the sunlit side of the earth. This is generally true for the minimum perigees of orbits with inclinations between about 40° and 50°, and comparable mean altitudes. Below 40° inclination, at these altitudes, the minimum perigee heights occur on the dark side of the earth. These considerations should be useful in selecting orbits for measuring diurnal variations in air density at high altitudes.

Note added in proof: In a previous report by Parkinson, Jones, and Shapiro [*Science* **131**, 920 (1960)], an error appears in Eq. 1. The first minus sign appearing in the equation should have been omitted. The equation should have read:

$$|\dot{c}(\theta)| \cong P\frac{A}{m}\left[\frac{3(2\pi-\alpha) + \sin\alpha}{4\pi n}\right]\cos\theta \quad (1)$$

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2. For the solar constant we have used the value 2.00 `Cal/cm² min, quoted in the American Institute of Physics Handbook with a probable error of 2 percent. Because of the uncertainties in KA/M, it is difficult to obtain from the Echo orbit a more precise value for the solar constant.
3. The use of the computer program employed in this work will be described in a forthcoming special report of the Smithsonian Astrophysical Observatory by P. Zadunaisky. The theoretical development on which the program is based can be found in a paper by G. Veis, *Smithsonian Contrib. Astrophys.* **3**, No. 9 (1960).
4. Preliminary calculations of the National Space Surveillance Control Center confirm the general trend of the orbit computed by Zadunaisky.
5. The trial expression for the eccentricity actually contained an additional time-dependent term whose coefficients were kept constant. This term incorporated the effects of the higher harmonics of the earth's gravitational field.
6. More accurately, the inverse of A/M was decreased at the constant rate of 0.0002 g/cm² per day.
7. Another possibility is to assume that the mass loss is uniformly accelerated (corresponding to a constant pressure and a constant micrometeorite puncture rate).
8. G. H. Pettengill, L. G. Kraft, MIT Lincoln Laboratory, private communication.
9. We considered the earth's shadow to be a right circular cylinder with a radius equal to that of the earth's mean equator.
10. The orbit determination is not yet precise enough to determine a scale height at the 1600-km altitude.

* Operated with support from U.S. Air Force.

6 September 1960

Observed Solar Pressure Perturbations of Echo I

Abstract. During the period 13 August to 22 August, day-to-day determinations of the average orbital elements of the 100-foot Echo I balloon, based on observations taken at the Jet Propulsion Laboratory's Goldstone tracking station, indicated a decrease in perigee height of 3.0 km/day and an increase in the eccentricity of 0.00038 per day.

The National Aeronautics and Space Administration satellite Echo I was placed in a 1000-mile nearly circular orbit on 12 August 1000 hours Universal Time with an inclination of 47.2°. This is a 100-foot aluminumized-plastic balloon which was launched for the purpose of inter- and transcontinental communications experiments.

The satellite was tracked for about three passes per day for a 10-day period with the Jet Propulsion Laboratory's 85-foot parabolic antenna at Goldstone, Calif. Angle observations were made with a precision of about 0.05°, and Doppler velocity with a precision of better than 1 m/sec for most of the passes. Each pass consisted of about 50 observations over a 10-minute interval.

On 13 August and 14 August data were taken for five passes (a 1-day arc) over Goldstone. By using the JPL orbit determination program (*1*) the Cartesian position and velocity were obtained for the epoch 13 August 1455 U.T. (*2*).

The Cartesian elements for the 13 August epoch were then integrated forward for a 10-day arc, using an Encke method which included perturbations due to the earth's oblateness, sun and moon gravitational effects, and a solar pressure term. Due to the height of the orbit, aerodynamic drag was neglected. A solar radiation pressure of 4.5×10^{-5} dyne/cm^2 was used, giving an acceleration of 5×10^{-5} m/sec^2 assuming specular reflection and a mass of 137 lb. During the integration over the 10-day arc the classical osculating elements were printed out at 45-minute intervals. These elements were then averaged over periods of 1 day to produce the solid curves for eccentricity, e, and perigee, q, shown in Fig. 1. These curves then represent the average values of the elements as predicted by numerical integration from the 13 August epoch.

The slope of the curves was determined graphically to be 0.00038 per day for the eccentricity and −3.0 km/day for the perigee.

The data points in Fig. 1 represent days on which the Goldstone station obtained data for two successive passes, that is, a 2.5-hour arc. For each of these, the orbit determination program was again used to obtain the Cartesian elements at an epoch near the beginning of the arc. These elements were then integrated forward for one period of the satellite (about 2 hours), and the classical osculating elements were printed at 6-minute intervals. These elements were averaged over the 2-hour period to obtain the points shown in Fig. 1.

The agreement of the data points determined day-to-day and the 10-day prediction, including an acceleration due to the solar radiation pressure, appears reasonable. The day-to-day determination of the semimajor axis, a, is also shown in Fig. 1. The fact that a remains constant within 1 km over the period of interest indicates that the assumption of negligible drag was valid.

The observed decrease in perigee of the Echo I satellite is substantially in agreement with that predicted by Parkinson, Shapiro, and Jones (*3*).

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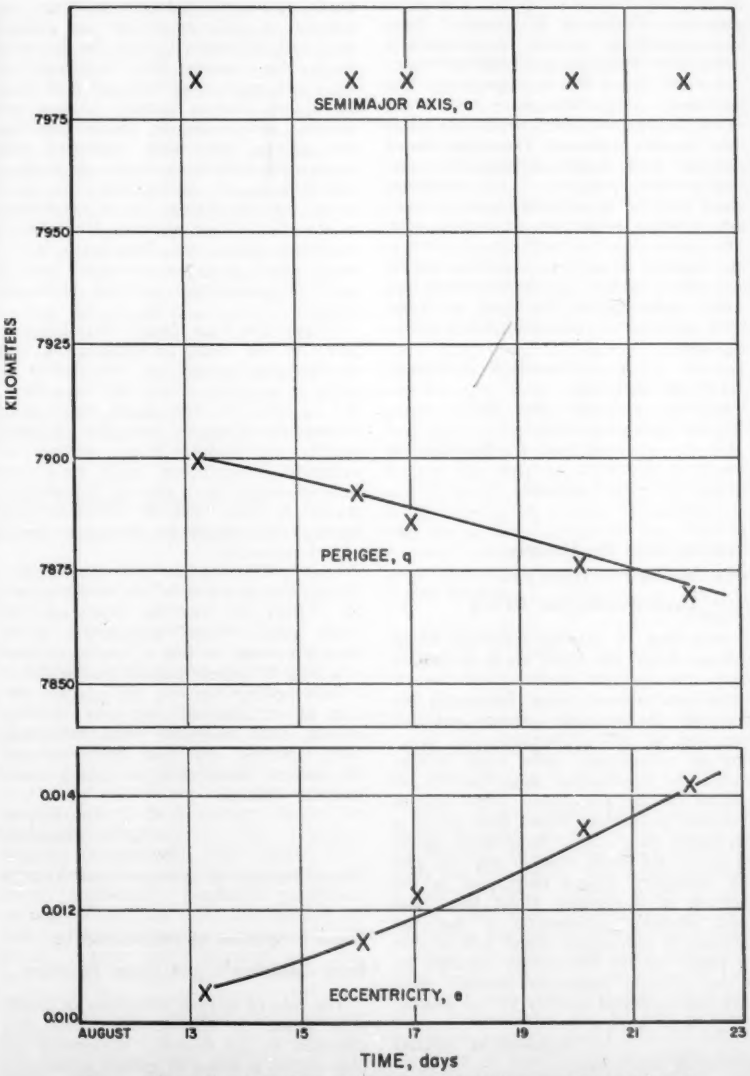

Fig. 1. Effect of solar radiation pressure on orbital parameters of Echo I.

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30 August 1960

National Academy of Sciences

Abstracts of Papers Presented at the Autumn Meeting, 14–16 November 1960, Philadelphia, Pennsylvania

Isotope Fractionation by Photosynthetic Organisms

When inorganic carbon is converted into living matter, the light isotope of carbon tends to be preferentially fixed.

Is this isotope fractionation characteristic of all living matter? Are there any significant differences in isotope abundances among specific compounds and, if such differences exist, can they be related to known biochemical processes? In an effort to answer these questions, the isotopic composition of the carbon in amino acids isolated from cultures of a number of photosynthetic microorganisms grown in the laboratory has been investigated. The major effort has been devoted to the green alga, *Chlorella pyrenoidosa,* which can be grown on an inorganic medium with the sole source of carbon being the carbon dioxide fed to the system.

A typical experiment consists of (i) culturing the algae, (ii) hydrolyzing the protein formed, (iii) separating pure amino acids by ion-exchange chromatography, (iv) combusting a portion of the amino acids to carbon dioxide, (v) decarboxylating a portion of the amino acids with ninhydrin and purifying the liberated carbon dioxide, and (vi) performing an isotopic analysis on the carbon dioxide with the mass spectrometer.

Individual amino acids and specific carbons within a single substance were found to possess widely differing isotope ratios. Some values of C^{12}/C^{13} relative to input CO_2 are leucine $\delta = -24$ per mil; aspartic acid, $\delta = -6.6$; carboxyl carbons of asparatic acid, $\delta = +2$; arginine, $\delta = -19$; and guanidino carbon of arginine, $\delta = +6$.

Our data suggest that CO_2 is fixed in a number of ways by photosynthetic organisms, which gives rise to these differing isotopic fractionations.

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Morphological Variants of the Bacteriophage P_1

In studying the fine structures of various bacteriophages with E. Kellenberger, we discovered a case of morphological variation in the bacteriophage P_1. Such variations are of interest because they raise questions as to the way in which the synthesis and assembly of structural elements of bacteriophages are controlled in infected bacteria. P_1 is a large bacteriophage with a relatively massive contractile tail 2200 A long and 200 A in diameter. Stocks of P_1 prepared from single particles contain particles with polyhedral heads of two different diameters: 650 A and 900 A, respectively. The two kinds of particles have been separated by centrifugation in cesium chloride density gradients. The large-headed particles have higher densities than the small-headed particles. It is therefore likely that the large-headed particles contain a larger proportion of nucleic acid. The interest here is twofold: (i) what is the function (if any) of the extra nucleic acid, and (ii) how are the structural elements (capsomeres) arranged to make head membranes (capsids) of two different sizes?

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Reflexes from the Heart—with Special Reference to a New Cardioaccelerator Reflex

According to existing information, all reflexes from the heart serve to inhibit heart rate and are mediated via the afferent and efferent vagus. Increasing the pressures in the right atrium and left ventricle, as well as intracoronary injection of veratridine, cause reflex bradycardia. In anesthetized dogs, partial occlusion of the pulmonary artery causes increased pulmonary blood flow which is dependent on an intact sympathetic innervation of the heart. Neither the vagi nor the medullary centers participate in the increase in pulmonary blood flow. The most probable explanation is that the increase in pulmonary blood flow is due to reflex cardiac stimulation initiated by a rise in right ventricular systolic pressure and mediated entirely by the cardiac sympathetic nerves.

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Cheek Pouch of the Syrian Hamster and Tissue Transplantation Immunity

It is now generally accepted that grafts of skin and other tissues exchanged between unrelated members of the same species (*homografts*) are soon destroyed by their hosts as a consequence of an immunological reaction evoked by "foreign," genetically determined, isoantigens present in the grafts. Heterografts—those of which donor and recipient belong to *different* species—suffer an even more rapid rejection.

One well-known exception to this generalization is the acceptance of a variety of tissue homo- and heterografts implanted into the wall of the cheek pouches of Syrian hamsters (*Mesocricetus auratus*).

Experiments have been carried out to investigate the basis of this apparently privileged environment, using three inbred strains of hamster. Orthotopic skin homografts exchanged between members belonging to *different* strains are consistently rejected within 12 days. On the other hand, skin homografts transplanted to the cheek pouches survive and proliferate for a long time in "virgin" (that is, untreated) hosts. However, specific sensitization of the latter with orthotopic skin homografts before, or at any stage *after,* implantation of homografts into their cheek pouches brings about destruction of the grafts. Thus, although incapable of sensitizing their hosts, homografts in the cheek pouch enjoy no exemption from a state of sensitization evoked independently.

It has also been found that if homografts of the "skin" constituting the wall of the cheek pouch are transplanted to recipient areas prepared in the integument, the majority live very much longer than homografts of normal body skin of much smaller size—indeed many survive indefinitely. Nevertheless, such grafts are fully susceptible to a state of sensitization elicited in their hosts by orthodox skin homografts or by donor leucocytes injected intravenously.

Further evidence has been obtained that the privileged status of the cheek pouch as a graft site and the uniqueness of cheek pouch "skin" homografts derive from properties of one of the ingredients —a layer of loosely packed areolar tissue.

This finding hints at the possible nature of mechanisms that may possibly prevent fetal mammals from sensitizing their mothers, and that may minimize the risk of occurrence of certain autoimmune diseases.

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Some Properties of Mitochondria from Cauliflower and Sweet Potatoes

The rate of oxygen utilization of many plant tissues is unaffected or even accelerated in the presence of cyanide or high partial pressure of carbon monoxide. Two hypotheses have been proposed in

the literature to explain the cyanide-insensitivity of such tissues. The first hypothesis suggests a pathway of electron transport to oxygen which is alternate to that provided by cytochrome oxidase. The second hypothesis is based on the assumption that there is an excess of oxidase compared with its substrate, cytochrome *c*. As yet there is insufficient evidence to allow a clear-cut decision between these two hypotheses.

In the experiments to be described a cyanide-sensitive tissue-cauliflower (*Brassica oleracea*) has been compared with a cyanide-insensitive one, sweet potato (*Ipomoea batatas*). In the presence of a suitable substrate the oxygen utilization of mitochondria prepared from both tissues is markedly influenced by adenosine diphosphate, the addition of which causes an increase of 5 to 10 times in the rate of oxygen utilization.

A careful study has been made of the respiratory capacities of these mitochondria. While no distinctive differences between the two types of mitochondria have been found, there are some marked characteristics that distinguish higher plant mitochondria from those derived from heartmuscle or liver. A study of the cytochrome components present in the mitochondria also shows no difference between the two types of plant mitochondria, but there are marked differences between the cytochromes present in plant and animal mitochondria.

The subtle difference between cyanide-sensitive and cyanide-insensitive plant tissues remains obscure in spite of the marked refinements that have been made in methods of mitochondrial preparation and in analytical methods.

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Virus Variants Obtained from Glycerinated Shope Papilloma

Shope papilloma virus prepared by alternate high and low speed centrifugation is usually thought to consist of fairly uniform particles. However, variations in size and density were observed in electron micrographs of our preparations, suggesting the presence of true structural variants. When such virus, prepared from glycerinated papilloma tissue, was suspended in cesium chloride solution having an initial specific gravity of 1.3070 and centrifuged at 35,000 rev/min for 24 hours, four distinct layers of opalescence appeared in the resulting density gradient. All four layers contained virus-like particles but only the lowest consistently produced papilloma on inoculation. This layer lost most of its activity when isolated and relayered, although initially active fractions were still active after storage for as much as 4 months in the cesium solution. The same four layers were obtained from different batches of papilloma of wild rabbits but not from glycerinated papilloma of domestic rabbits. The latter contain little or no virus. Suspensions of virus initially subjected to 100 freezings and thawings produced the same layers with corresponding infectivities. This stability, together with the consistency of isolation from different papillomas, suggests that the variants exist in the papilloma tissue of origin. The loss of infectivity of the lowest layer upon purification may possibly be due to separation from some necessary cofactor in the gradient.

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Use of Spider Monkeys (Ateles) in the Study of Gastric Secretion

Previous reports on the composition of gastric contents in monkeys have been confined almost entirely to *Macaca mulatta*. Material obtained by peroral intubation was found to have a *p*H above 3.5 in the fasting state. No acid response to histamine stimulation was obtained in some specimens. We have studied nine spider monkeys equipped with chronic gastric fistulae or innervated gastric pouches for periods up to 3 years. Fasting content from the fistula showed total acid concentrations of from 99–127 mEq/liter with the animal in its cage and less when restrained in a chair. The maximal total acid concentration after histamine stimulation was 130–141 mEq/liter, and after insulin hypoglycemia, 98–138 mEq/liter. Pepsin and electrolyte determinations were made also. An innervated gastric pouch was observed to secrete hydrogen ion at the rate of 0.4 mEq/hr during feeding. The cannulae of both fistulae and pouches were well tolerated and 24 hour collections with the animal in its cage or on a leash were obtained. The use of such animals in the study of nervous control of gastric secretion may have unique advantages including application to man.

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Conformations of Substituted Cyclopentanes. II. Ring D in the Steroids

While several authors have commented on the structure of *trans*-fused ring D in the steroids, no comprehensive structural study has been made. This report presents a conformational analysis which is consistent with recent experimental evidence relating to this five-membered ring system.

There are three important conformations to be considered consisting of two envelopes and one half-chair [Brutcher *et al.*, *J. Am. Chem. Soc.* **81**, 4915 (1959)]. Envelope conformation I has C_{14} below the plane of C_{13}, C_{15}, C_{16}, C_{17}, while half-chair conformation II has C_{13} above and C_{14} below the C_{15}, C_{16}, C_{17} plane. An additional envelope conformation (III), hitherto neglected, has C_{13} above the plane of C_{14}, C_{15}, C_{16}, C_{17}. In particular, it is demonstrated through infrared techniques that 16-halo-17-keto steroids prefer envelope conformation I. This is in contrast to Shoppee's analysis of these haloketones. The conformations of steroids with other ring D substituents have been analyzed and will be discussed.

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Central Determination of Sensory Processes

Recent anatomical and physiological studies have implied that it is the diffuse reticular core of the central nervous system which exerts a vital tonic regulatory influence on the sensory systems, thereby modulating incoming sensory data in accordance with the central state of the organism or the behavioral significance of the stimulus.

We have obtained anatomical and electrophysiological evidence which reveals that there are direct neural pathways from the highest central level of sensory projection, the cerebral cortex, back to sensory relay stations of the somasthetic system. Observations of the electrical activity of individual second order nerve cells concerned with touch of body parts illustrate that these cells can be directly excited or blocked by neural activity generated in the same sensory cortical area to which these cells project. Spatial (somatotopic) relations are preserved throughout the system.

Such a system might operate so as to (i) refine the attributes of sensation, (ii) organize perception, (iii) form the early stage of mnemonic processes, (iv) set the receptive tone of the modality, or (v) initiate phenomena in the absence of peripheral stimuli.

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Selective Conversion in vitro of Phage-Specific Ribonucleic Acid to Deoxyribonucleotides

Uracil-2-C^{14} was incorporated into T6r$^+$-infected *Escherichia coli* strain B_{6-} to produce a ribonucleic acid (RNA) comprising 4 percent of the total RNA and mimicking the base composition of T6 deoxyribonucleic acid, rather than the bulk of *E. coli* RNA. The phage-specific RNA selectively disappears from extracts of infected cells. The fate of the labeled pyrimidine ribonucleotides was determined, using a system of analysis which could differentiate small amounts of labeled pyrimidine ribonucleotides, deoxyribonucleotides, and arabinonucleotides.

In the presence of exogenous reduced triphosphopyridine nucleotide (TPNH) there was a rapid synthesis of pyrimidine deoxyribonucleotides from the ribonucleotides of the specific RNA. At least half of the label of the RNA which disappeared was converted to deoxynucleotide. About 20 percent of the isotope of the RNA appeared as 3′-ribonucleotide, and the system also generated a small amount of free labeled uracil. It was demonstrated that the absence of exogenous TPNH, but not of DPNH, inhibited the production of deoxyribonucleotides by over 80 percent. In the absence of TPNH in the incubation mixture, 5′-CMP accumulated in the acid-soluble fraction. The formation of dCMP was shown to be correlated with the disappearance of preformed, or newly generated, 5′-CMP.

In the presence of an excess of unlabeled UTP and CTP, the formation of labeled deoxyribonucleotides from labeled phage-specific RNA was markedly depressed, although the release of 5′-CMP was not depressed. On the other hand, deoxyribonucleotides could be formed rapidly from labeled acid-soluble nucleotides, and the presence of an excess of unlabeled phage-specific RNA did not depress this appearance of labeled deoxy compounds. It was concluded that phage-specific RNA released 5′-nucleotides to the acid-soluble fraction. In the presence of TPNH these 5′-ribonucleotides were rapidly converted to deoxyribonucleotides.

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Binding of Reduced Diphosphopyridine Nucleotide to Yeast Alcohol Dehydrogenase According to Chemical Relaxation by Temperature Jumps

The binding of DPNH (reduced diphosphopyridine nucleotide) to various dehydrogenases is associated with an increase in the fluorescence of DPNH [H. Theorell, *Adv. Enzymology* **20**, 31 (1958); *Acta Chem. Scand.* **14**, 933 (1960)]. The binding to YADH (yeast alcohol dehydrogenase) appeared to be most suitable for the investigation with the temperature jump method. The chemical relaxation of this system is followed fluorometrically with a pulse oscilloscope (Tektronix 545). Two different equilibrium shifts with their relaxation times τ_1 have been established so far; a small shift with $\tau_1 \sim 100$ msec and a larger shift with $\tau_2 \sim 100$ μsec. The first is attributed to the association step:

$$\text{YADH} + \text{DPNH} \rightleftarrows \text{YADH, DPNH}$$

The exact kinetic relationship has not as yet been established as some fast equilibria are expected to be coupled to the above reaction:

$$\text{YADH} + \text{H}^+ \rightleftarrows \text{YADH}^+ \quad (1)$$
$$\text{YAD}^- + \text{H}^+ \rightleftarrows \text{YADH} \quad (2)$$

where reaction 1 shows equilibria involving hydrogen bonding, and reaction 2 shows equilibria involving refolding of enzyme (—parts).

One might also have to take into account reactions involving the transition of excitation energies, including also inter- and intramolecular resonance energy transfers and singlet-triplet conversions. The fast relaxation time τ_2 has so far been attributed to some *p*H effect. Detailed investigations on both τ_1 and τ_2 are in progress.

Temperature jumps are produced by the discharge of a high-voltage capacitor through the solution containing the reactants [*Z. Elektrochem.* **64**, 78 (1960)]. The fluorescence is excited at 360 mμ from a BH6 Hg-arc and measured at right angles to the exciting beam at 410 mμ. The current at the photomultiplier anode reaches 1 ma (amplification = 200). The signal-to-noise ratio in actual measurements of $\tau_2 \sim 100$ μsec is 100 with an equilibrium shift of 5 percent of the signal at *p*H 6.5. Artifacts due to the high voltage discharge through the enzyme solution are negligible above about 10 μsec after its triggering.

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Comparative Study of Genetic Effects Induced by X-Rays, Ultraviolets and 2-Aminopurine

In the *cys. C.* region of the chromosome of *Salmonella typhimurium*, three types of changes have been detected, namely, single site, short deletions, and long deletions. Data will be presented showing that relative frequencies of these three types differ among the mutants of spontaneous origin and mutants induced by x-rays, ultraviolet radiation, or 2-aminopurine. This research was carried out under the auspices of the U.S. Atomic Energy Commission.

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Correlation of Physical and Chemical Events in Sympathetic Ganglia

Pre- and postsynaptic slow potentials arise spontaneously in rat sympathetic ganglia after infection with pseudorabies virus. In early infections postsynaptic slow potentials are derivatives of the presynaptic slow potentials. In advanced infections postsynaptic slow potentials, and not their derivatives, are similar to presynaptic slow potentials; that is, both potentials are identical. In intermediate infections the first wave of a postsynaptic burst of activity is a derivative of the corresponding presynaptic wave; the remaining presynaptic and postsynaptic waves in correspon..ng bursts are identical. It is believed that the spontaneous origin and characteristic formation of these potentials are the result of a progressive inactivation by the virus of inhibiting and differentiating mechanisms located in the presynaptic nerve endings. It is suggested that within sympathetic ganglia there are mechanisms capable of forming and transmitting a wide range of responses from the multitude of nerve impulses reaching it from the central nervous system. At one extreme would be the formation and transmission of a response which is a perfective derivative of the presynaptic potential; the other extreme would be where no differentiation occurs. The role of acetylcholine is to increase the frequency and amplitude of the presynaptic potential. Because physostigmine can change an early stage of infection into a late stage within a matter of seconds, it is suggested that cholinesterase is a part of the differentiating mechanism.

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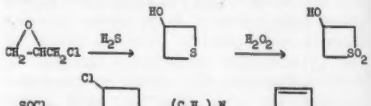
Synthesis and Reactions of Derivatives of Thietene and Thietane

The first synthesis of the previously unknown thietene sulfone has been accomplished by a four-step sequence.



Its structure has been confirmed by hydrogenation of the double bond (which gives the known thietane sulfone) and by its nuclear magnetic resonance spectrum. The NMR spectrum of thietene sulfone in deuterochloroform at 60 mc with tetramethylsilane as a standard shows sets of signals at 274 cy/sec for the methylene (CH_2) protons, at 408 cy/sec for the α-olefinic proton and 434 cy/sec for the β-olefinic proton. Therefore, the β-olefinic proton is least shielded from the applied magnetic field. This may be interpreted as indicating delocalization of the electrons in the system comprised of the carbon-carbon double bond and the sulfone group.

The infrared spectrum of thietene sulfone also is in agreement with the proposed structure and shows an unusually high C–H stretching frequency (3165 cm^{-1}) and an unusually low C=C stretching frequency (1543 cm^{-1}).

The carbon-carbon double bond is reactive towards various nucleophilic reagents. For example, dimethylamine and thietene sulfone give 3-dimethylaminothietane-1,1-dioxide. This is reduced by lithium aluminum hydride to 3-dimethylaminothietane. Pyrolysis of the quaternary ammonium hydroxide did not yield the unknown, four-membered, cyclic unsaturated sulfide, thietene.

Thietene sulfone gives a Diels-Alder adduct with anthracene which can be reduced with lithium aluminum hydride to the Diels-Alder adduct of thietene. Cracking this adduct gave anthracene and a nonvolatile oil, possibly a polymeric derivative of thietene.

The sulfone shows unusual behavior on reduction with lithium aluminum hydride. When the reduction was carried out at 45°C in a mixture of diethyl and di-*n*-butyl ethers, the only volatile product was

n-propyl mercaptan. No thietane was ever found. At 0 to 5°C the reduction was slow and the main product was still *n*-propyl mercaptan, but there were seven other components present (excluding solvent) as shown by gas chromatography. Sodium borohydride reduces the carbon-carbon double bond of thietene sulfone to give thietane sulfone.

When thietene sulfone is treated with aqueous sodium hydoxide, dimethyl sulfone is produced.

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Independent Biosynthesis of Hemin and Globin in Hemoglobin

Essential information has been lacking to permit a reliable interpretation of earlier findings on the relative labeling of the hemin and protein moieties of hemoglobin, with such agents as glycine-2-C^{14}. A major opinion has been that these disparate portions of the hemoglobin molecule are biosynthesized at the same rate and from the same amino acid pool. On the other hand, experimental data reported from our laboratory has supported the conclusion that there was a separation in the biosynthesis of the hemin and protein moieties of cytochrome *c*. The present work upon dog hemoglobin, labeled in vivo with glycine-2-C^{14}, supplies direct data upon the relative labeling per glycine-carbon in both hemin and globin. In most previous studies this necessary information has been derived by calculations, based upon questionable assumptions.

The amino acid spectrum of the globin of dog hemoglobin was determined quantitatively by the Moore and Stein technique. Relevant in the present connection there were 41.3 residues of glycine and 34.0 residues of serine in the protein molecule. The following labeling data were obtained: (i) The radioactivity in the globin was accounted for completely by that in glycine and serine. (ii) 58.9 percent of the globin radioactivity was present in the glycine. (iii) When the radioactivity values of the glycine and serine were adjusted for their relative molecular weights, the serine molecule had 90 percent of the activity of the glycine molecule, suggesting that these two amino acids had come to equilibrium quickly in the body pool or pools. (iv) The ratio of specific activities (counts per minute per milligram) of hemin to globin was 9.46, and that of counts per minute per mole of globin to hemin was 10.3. (v) The ratio of activities per glycine-carbon in globin to glycine-carbon in hemin was 1.18, a value probably significantly greater than unity. Since this ratio is not appreciably greater than unity, further work is in progress to fully establish its validity.

These findings do not lend support to the concept that in the biosynthesis of hemoglobin the hemin and protein moieties are made at the same rate from the same amino acid pool. They are consistent with the tentative viewpoint of an independence of hemin and globin biosynthesis in the construction of hemoglobin. They are also consistent with the possibility that the fabrication of the protein may be the rate limiting process in the synthesis of hemoglobin.

This work was supported by a grant from the National Science Foundation.

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Mechanisms of Gas Exchange and Oxygen Transport in Man

Rapid gas exchange between the pulmonary alveoli and the blood entering the pulmonary capillary bed has been recorded with a whole body plethysmograph to measure the volume of nitrous oxide absorbed per unit time after a single breath of 80 percent N_2O. The rate of gas absorption was proportional to the rate of blood flow, the gas concentration, and the solubility of the gas in blood. With this technique, pulmonary capillary blood flow was found to vary with the vascular pressure gradient during the cardiac cycle, flow lagging behind pressure by less than 0.1 second. The pressure-blood flow and pressure-blood volume characteristics were measured in isolated and perfused animal lungs. Abnormalities of these relationships were demonstrated in patients with pulmonary hypertension. The method yielded the same value for blood flow as that obtained by measuring the rate of oxygen transport from the lungs using the direct Fick method. The rate of pulmonary capillary blood flow also depends on the metabolic rate of the body. Therefore, a theoretical study was made of oxygen tension gradients within the tissues. The relationship between tissue oxygen tension and the rate of oxygen consumption, investigated by others, appears to indicate that oxygen tension at the site of utilization is much less than at the cell surface. A diffusion gradient between the cell surface and the site of utilization may exist if the radius of reaction is small, that is, if steady state reactions take place at small foci. Indirect evidence for this hypothesis has been adduced from the literature on chemical reaction rates at different oxygen tensions in whole cells, particulate fractions, and chemical extracts of cells. If it is true, such concentration gradients to and from small sites of reaction may explain the potential and osmotic gradients in cells.

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Role of Adipsia in Lateral Hypothalamic Starvation

Feeding and drinking behavior is being studied in rats with lateral hypothalamic lesions. For some time after surgery these animals neither eat nor drink and will die in the presence of food and water. In the original descriptions of this phenomenon the cessation of feeding (aphagia) was emphasized and the lateral hypothalamus was seen as the site of a "feeding center."

However, if offered a liquid diet, many of these animals will recover feeding behavior, regulate calories, and maintain body weight after operation, although at this same time they will not accept tap water (adipsia) or dry food. They can then be weaned to a nonnutritive saccharine solution and as their weight declines they inevitably begin to eat dry food. If the saccharine is removed and only tap water is offered, they do not drink, and they stop eating dry food and begin to starve again. Intragastric hydration restores dry food intake. These animals, therefore, do not eat because they do not drink. In this stage of the recovery from lateral hypothalamic damage, adipsia, not aphagia, is the deficit produced by the lesions.

However, adipsia does not account for the entire syndrome immediately after operation. Depending upon lesion size, aphagia of variable duration may occur postoperatively despite adequate hydration.

In summary, except for this variable postoperative aphagia, the failure to eat and drink that is seen in rats with lateral hypothalamic lesions is caused by a prolonged adipsia.

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Phyllotactic Constants in Growth of the Shoot Apex of Xanthium

Consideration of the mathematical models of phyllotaxis suggests that the spiral arrangement of leaf primordia at the shoot apex of many plants can best be specified by quoting (i) the *divergence angle* between successive primordia and (ii) the *plastochron ratio*, that is, the ratio of distance of successive primordia from the center of the apex. The plastochron ratio can be interpreted as a growth rate. A statistical method for estimating these constants has been devised and applied to transverse sections of shoot apices of *Xanthium*. The resulting divergence angle of 133.25° and plastrochon ratio of about 0.5 differ significantly from theoretical values which have been quoted for a 2:3 phyllotactic pattern.

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Efficiency of Active Chloride Transport by the Gastric Mucosa

The net active transport of chloride by the gastic mucosa is the sum of the electric current of chloride ions and the hydrochloric acid secretion. Bullfrog gastric mucosa was mounted between two chambers and current was passed to maintain the natural membrane potential at zero so that the mucosa maintained a current through zero external resistance.

Oxygen consumption was measured polarographically and Cl^{36} was used to measure unidirectional fluxes. The ratio of the short-circuit current of chloride ions to oxygen molecules consumed in 50 experiments was from 0.9 to 5.4. Two values were certainly above 4.0 (5.1 and 5.4), the electrochemical equivalent of oxygen. When the sum of hydrochloric acid and the short-circuit chloride current was compared to the oxygen consumed, 13 of 22 values of the ratios were 4.0 (maximum of 7.3). Direct measurements of net actively transported chloride, while the transmembrane potential was held at zero, similarly gave ratios significantly above 4.0. Since some oxygen must be used by the tissue for other purposes, these results demonstrate clearly the inadequacy of a simple redox pump hypothesis, with oxygen as the sole electron acceptor, for the active transport of chloride across the gastric mucosa.

It is interesting that $SO_4^{=}$ Ringer solution abolished the chloride current but that the oxygen consumption did not fall. In NO_3^- Ringer solution a current quite similar to that produced by chloride was maintained for several hours.

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Studies of Oxidative Phosphorylation Using Submito-chondrial "Digitonin" Particles

A series of studies has been undertaken to compare the properties of the endogenous pyridine nucleotides of rat-liver mitochondria and submitochondrial particles derived by digitonin treatment (RLMD) (Lehninger) and to relate these to the reactions associated with the phosphorylation of adenosine diphosphate occurring concomitant with the oxidation of substrates. These reactions involve the fluorometric measurement of very low concentrations of pyridine nucleotide which have been carried out simultaneously with the polarographic determination of the rate of oxygen utilization.

The following propositions were considered concerning RLMD and will be discussed: (i) The stoichiometry of pyridine-nucleotide concentration to cytochrome content and its interpretation in terms of units or assemblies of respiratory chains. (ii) The functional activity of this pyridine nucleotide and its relationship to betahydroxybutyric dehydrogenase and succinic dehydrogenase as well as other residual dehydrogenases retained during the isolation procedure of RLMD. (iii) The possible involvement of reduced pyridine nucleotides in oxidative phosphorylation and the changes in extent of steady-state reduction occurring during the phosphorylation reaction and, (iv) The number of sites of phosphorylation operative during betahydroxybutyrate or succinate oxidation, or both.

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Nature of the Biochemical Changes in Adenovirus Infected Cells

Adenovirus infection of HeLa cells results in a marked increase in deoxyribonucleic acid as well as protein. It was demonstrated that infected cells contain two species of DNA: the normal host cell component (termed water-soluble DNA), and a fraction which accumulates subsequent to infection (termed saline-soluble DNA because its nucleoprotein complex is soluble in 0.15*M* NaCl). Investigation of the synthesis of DNA in type 4 adenovirus infected cells utilizing radioisotopes demonstrated that the synthesis of saline-soluble DNA but not water-soluble DNA was increased. Detailed study of the saline-soluble DNA indicated that it was synthesized *de novo*; that it was derived from precursors in the cell and from the media; that its synthesis commenced 2 to 3 hours before detectable infectious virus, and that it was probably a viral precursor. Nucleotide and base analyses of DNA from uninfected and infected cells showed the saline-soluble DNA from infected cells to be unique to the infected cell in that it did not have the characteristic base-pairing as did normal host cell DNA. The guanine was particularly increased in content, and isotopic investigations indicated an increased synthesis of this purine.

Ribonucleic acid was increased approximately 30 percent by infection, but the RNA was not of unusual structure. Protein of infected cells was increased about 100 percent and, with Wilcox, was shown to consist of three immunologically distinct antigens separable from the viral particle.

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Some Properties of a Protein Component of the Cell in Constant Migration between Nucleus and Cytoplasm

Studies on nucleocytoplasmic interactions suggest that sizable biological molecules show only unidirectional movement. It is believed, for example, that ribonucleic acid migrates only from nucleus to cytoplasm and that energy sources presumably move only from cytoplasm to nucleus. Consequently, it was a unique observation to find, in *Amoeba proteus*, a protein(s) which is in constant, *nonrandom*, back-and-forth migration between nucleus and cytoplasm.

This can be demonstrated by grafting a nucleus with radioactively labeled protein into a cell with a nucleus. Within 1 hour, one finds that the cytoplasm is lightly labeled but the nucleus of the recipient cell is very markedly labeled (as is, of course, the grafted nucleus). This most likely represents a movement of the protein into the cytoplasm followed by a rapid return to the nucleus.

Additional experiments demonstrate that: (i) during this cycle of activity the material must be at least a polypeptide; and (ii) it contains methionine, lysine, and tryptophan (the only amino acids thus far tested). The presence of tryptophan argues against its being a histone.

Its primary localization in the nucleus suggests the protein may be related to the cell's genetic material. To test this, an investigation was made of its metabolic stability. While in some instances the protein was stable for at least 9 days and several cell divisions, in other cases it broke down after only 3 to 4 days and one cell division. Although not definitive, the evidence suggests that this protein does not have the stability one expects of genetic material.

The possible role of this protein in the physiology of the cell will be discussed.

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Genetic Alteration of Adenylosuccinase in Salmonella typhimurium

Mutations occurring in the *ade-B* locus of *Salmonella typhimurium* lead to the loss of activity of adenylosuccinase, a bifunctional desuccinylating enzyme required for two reactions in the biosynthesis of adenylic acid. Complete or partial restoration of enzymic activity can be obtained in such mutants by a variety of genetic changes. One such alteration involves a nonallelic suppressor mutation which allows phenotypic expression of the wild-type in presence of the original mutant gene. The suppressor mutant grows in the absence of adenine at one-third the growth rate of the original wild-type, accumulates the substrate of the first blocked reaction and contains adenylosuccinase activity at level of 5 to 15 percent of the wild-type activity. Comparisons of the restored activity in the suppressor with that of the wild-type show no significant differences with respect to K_m, heat stability, effect of inhibitors, and competition for substrates. However, striking differences are found in activities of extracts which have been dialized following precipitation of nucleic acids with streptomycin, protamine, or $MnCl_2$. Whereas the wild-type enzyme survives this treatment with no loss of activity, the suppressor enzyme is completely and irreversibly inactivated. Glutathione cannot restore activity but can partially prevent its loss if present during dialysis. The suppressor enzyme also differs from the wild-type enzyme in its resistance to inactivation at *p*H 8.0 and by antibodies prepared against wild-type enzyme. These differences may indicate that the *ade-B* mutation leads to an altered protein whose enzymic inactivity can be partially activated by a suppressor mutation.

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Morphogenesis and Cell Wall Structure in Growing Algal Cells

Elongating roots, stems, and other cylindrical plant organs extend through the elongation of individual cylindrical cells. The elongation process is especially

easy to study in certain algae where the cells occur either singly or in simple configuration. The expansion process may be considered as the result of the yielding of the semi-solid outermost part of the cell, the cell wall, to the osmotic pressure developed in the large vacuole in the cell interior. By this model of growth, the highly polar (cylindrical) expansion of the cell must be a function of inequalities in the ability of the wall to yield in various directions. The wall is strong in the transverse direction; it is weak in the longitudinal direction. Strength is associated with the alignment of a great many crystalline cellulose microfibrils in the transverse direction inside the wall. During the elongation process new transverse microfibrils are added to the inner surface of the wall. Experiments with *Nitella* involving (i) the artificial cessation of expansion in part of an elongating cylinder, (ii) the virtual elimination of the transverse component of expansion, and (iii) the virtual elimination of the longitudinal component, indicate that alignment takes place along lines at right angles to the direction of the maximum surface expansion. When expansion is artificially stopped, the alignment becomes very poor. When either the transverse or the longitudinal component is restored, alignment is perpendicular to this component. Thus the alignment aspect of wall synthesis bears a perpendicular relation to the direction of maximum wall expansion at the time of synthesis.

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Studies of Antibody Formation by Transfer of Lymph Node Cells

Studies of the site of synthesis of antibodies have indicated that they are produced chiefly in organs of the lymphatic system. More recently, it has been found that cells can be obtained from lymph nodes of animals injected with antigens and transferred to other (recipient) animals with the appearance in the serum of the recipients of antibodies to the antigen injected into the donor animals. In the studies to be reported here it has been found that lymph node cells can be obtained from uninjected donor animals, incubated in vitro with certain antigens and transferred to recipient animals, with the subsequent appearance of the corresponding antibody. In the in vitro incubation of lymph node cells with antigen it has been found that within 5 minutes of incubation enough of the antigen has been taken up by the cells to lead to maximal formation of antibody by these cells; and, with certain assumptions, it has been possible to estimate that at most a few hundred molecules of this antigen are taken up by each cell during this incubation.

This experimental situation, involving the transfer of cells among rabbits within a genetically heterogenous stock, has introduced immunologic reactions to antigens of the transferred cells themselves. The prior injection of donors' leukocytes to prospective recipients was found to stimulate an immunologic reaction against the donors' individual cell-antigens which led to the suppression of antibody formation by donors' lymph node cells subsequently transferred to these recipients. In sera of rabbits injected with leukocytes of other rabbits, it has been possible to demonstrate the presence of antibodies to rabbit cell antigens, since these sera can cause suppression of the synthesis of antibody by transferred lymph node cells.

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Role of Phosphorylase Activation in the Cardiovascular Action of Drugs

In the perfused rat heart it has been found that the increase in force of contraction produced by sympathomimetic amines is closely associated with an increase in the activity of phosphorylase *a*. Methyl xanthines, such as theophylline, in doses which produce cardiac stimulation also cause activation of phosphorylase.

In the intact rat, the level of activity of cardiac phosphorylase *a* varied widely depending on the prior treatment of the animal. Decapitation caused a marked increase, and anesthesia with pentobarbital or ether a decrease, in enzyme activity. Pretreatment of the animals with hexamethonium or bretylium, which by different mechanisms depress the sympathetic nervous system, caused a decrease in phosphorylase *a* activity in the heart. Administration of reserpine which has been shown to deplete the heart of catecholamines was also found to decrease the activity of phosphorylase *a*.

Finally, it was observed that in hearts perfused with Locke solution there was a rapid fall in phosphorylase *a* activity.

The experimental findings described above will be discussed in relation to the work of Sutherland, Rall, and co-workers on the action of drugs on the intracellular synthesis of cyclic 3′, 5′-adenylic acid.

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Recent Work at the National Radio Astronomy Observatory

The first observing instrument at the National Radio Astronomy Observatory, an 85-foot diameter radio telescope, has now been in operation about 18 months. The general research program of this instrument will be briefly outlined. Much of the work, by staff and visiting astronomers, is directed to the general problem of galactic structure and evolution, through observations of regions and objects of particular interest in our galaxy and of the discrete sources of radio emission that lie beyond the galaxy. The current status of two continuing programs in this area will be discussed. These two programs are concerned with the determination of precise positions of radio sources and the study of spectra of sources.

The National Radio Astronomy Observatory is operated by Associated Universities, Inc., under contract with the National Science Foundation.

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Cross-reactions between Salmonella and Pneumococcus

Type-specificity in *Salmonella* has been shown by Westphal, Staub, and co-workers to be due largely to terminal nonreducing groups of 3, 6-dideoxy-sugars in the so-called O-lipopolysaccharide antigens in the cell walls of these microorganisms. In *Pneumococcus*, type-specificity derives from the unique structure and chemical composition of the extramural capsular polysaccharide of each type, and dideoxy-sugars have not yet been found. The three sugars, D-galactose, D-glucose, and L-rhamnose occur frequently in the type-specific and group-specific sequences of *Salmonella* and in the capsular substances of *Pneumococcus*, so that cross-reactions of precipitation or agglutination between a member of one of these two large groups of pathogens with a strain of the other group would not be surprising if one or more of these sugars should occur multiply and similarly linked in the determinant antigens of both. Several instances of such cross-reactivity are recorded in the present study, in addition to the few already noted, and are discussed in terms of the incomplete present chemical knowledge of the polysaccharides involved.

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Persistent Viral Infections

The majority of viral infections of man or animal remain silent. Furthermore, many viruses may persist in the host after recovery from illness. Several factors conceivably control these states of latency, but their pertinence and importance cannot readily be assessed in intact hosts. Cell cultures offer a simplified system for study of latency, and many examples of persistent viral infections in cell populations have been recorded [H. S. Ginsberg, *Progr. med. Viol.* **1**, 36 (1958)]. Some of these require antiviral sera, inhibitors, or changes in cultural conditions. In others, interference and interferon production limit viral reproduction, as shown by my associates and myself [Henle, *et al.*, *J. Exptl. Med.* **108**, 537 (1958); Bergs, *et al.*, *ibid.*, 561; Deinhardt, *et al.*, *ibid.*, 573; Henle, *et al.*, *ibid.* **110**, 525 (1959)].

On inoculation of MCN cultures with Newcastle disease virus (NDV) maximally 30 percent of the cells became infected but the incidence rapidly decreased and was maintained at about 1 percent for years. Yet, infected lines showed reduced

growth rates, increased aerobic glycolysis, and resistance to superinfection with other viruses. Cures by anti-NDV serum were rare but cloning under antibody yielded virus-free populations indistinguishable from cloned parent cells.

Infected cells contained only one infectious unit at a time. On transfer of a few to uninfected cultures the infection spread slowly with doubling of virus every 6 to 8 hours until about 1 percent of the cells became infected. At this stage, all remaining cells resisted superinfection. A component other than virus was produced which induced resistance and resembled interferon [A. Isaacs and B. W. Lacey, Eds., *Virus Growth and Variation* (Cambridge Univ. Press, London, 1959) pp. 102-121].

Evidently MCN cells vary in competence, which is not genetically controlled. Interferon, produced by NDV infection, reduces the number of competent cells. Since interferon protection is transitory, interferon and virus compete for cells regaining competence. If the virus wins, more interferon is produced, in turn; when protection wears off, more virus can be replicated. Thus, interferon and virus are kept in balance and both virus and cells persist in culture.

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Loss of Phenotypic Traits by Differentiated Cells in vitro

Do the cultured progeny of differentiated tissue cells inherit the unique somatic traits of their parental cells much as bacteria inherit genes determining constitutive or inducible enzymes or as paramecia inherit genes determining serotypes?

An unambiguous approach to this problem requires that; (i) the initial population of differentiated cells be homogeneous, and (ii) all the differentiated cells divide during the experiment. These conditions are satisfied by liberating chondrocytes from the matrix of embryonic cartilage (by means of trypsin), rearing them in culture for varying periods of time, and then testing the progeny of the chondrocytes for their capacity to differentiate into cartilage cells.

Freshly liberated chondrocytes immediately organ-cultured (that is, before they divide mitotically) proceed to form new matrix. Over 98 percent of these cells synthesize chondroitin sulfate and incorporate sulfur-35 into ester bound sulfate. After being cultured as a monolayer for 8 days (generation time 30 hours), the progeny of chondrocytes when organ-cultured or grafted to the coeloem (i) fail to differentiate into chondrocytes, (ii) fail to synthesize chondroitin sulfate, and (iii) fail to incorporate sulfur-35 into ester bound sulfate.

These results suggest that (i) the differentiated state of a cultured tissue cell may not survive rapid multiple mitotic divisions and that (ii) the differentiated state of a cultured tissue cell is not exclusively (primarily?) a function of the genetic constitution of the cell's nucleus.

This work was supported by grants from the U.S. Public Health Service.

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New Experiments on Interactions of Electrons with Quantized Lattice Vibrations (Phonons)

Interactions of electrons with phonons have been investigated on samples which allow the process to be studied in the classical configuration of source, propagation medium, and receiver [see also K. Hubner and W. Shockley, *Phys. Rev. Letters* **4**, 10, 504 (1960)]. This is accomplished with very thin plates of single crystal silicon, into which phosphorus has been diffused in order to render the regions close to the surface electron conductive. (Such procedures are common practice in the semiconductor industry.) The resulting structure is like a three-layer sandwich with the two outer layers containing free electrons capable of carrying current and the middle layer forming an electrically isolating barrier between them. An electric field is applied along one of the outer layers, and the resulting flow of electrons disturbs the equilibrium distribution of the phonons due to electron-lattice interactions. This disturbance propagates through the sample and in turn acts upon the electrons in the other outer layer, resulting in a measurable induced electric field. The approximate range of the effect is an average mean path of the phonons, although some effect is detected out to 1 mm at 77°K, about 10 mean free paths. Systematic measurements of the induced field and its dependence on thickness and chemical purity of the middle layer yield interesting information on propagation of atomic vibrations in silicon. In addition, this effect might have practical applications, including possibly a direct current transformer.

This research was sponsored by the Office of Naval Research.

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Orientation of Cell Growth by Polarized Radiation

Four years ago it was reported that zygotes of the intertidal "rock weed," *Fucus*, germinate parallel to the vibration plane after exposure to plane polarized visible light [L. Jaffe, *Science* **123**, 1081 (1956)]. Further study led to the conclusion that this "polarotropic" response is a variant of the general phenomenon of phototropism and is mediated by a periclinal orientation of dichroic photoreceptor molecules; that is, the axes of maximum molecular absorption lie parallel to the nearby surface of the zygote [L. Jaffe, *Exptl. Cell Research* **15**, 282 (1958)]. Similar polarotropic responses were also discovered in the spores of a moss, a fern, and the imperfect fungus, *Botrytis* [E. Bünning and H. Etzold, *Ber. deut. botan. Ges.* **71**, 304 (1958)].

In this paper, we report proof that the polarotropic response of *Botrytis* spores is also a variant of phototropism mediated by an orientation of dichroic photoreceptor molecules with respect to the nearby surface. However, in this case it is shown that the axes of maximum absorption of these molecules, unlike those in *Fucus*, are anticlinal; that is, they are perpendicular to the nearby surface. We also report a somewhat less rigorous analysis of the polarotropic responses of the spores of the fern, *Osmunda*, indicating periclinal photoreceptors similar to those in *Fucus*. Again, we report a preliminary study of the polarotropic responses of the spores of the moss, *Funaria*. This indicates a situation which is anomalous not only in a high responsiveness to red light, but also in the presence of at least two different tropic photoreceptor molecules, one of which is *un*oriented while the other is anticlinal. Finally, we report a qualitatively new aspect of the tropic responses of *Botrytis* spores to light, the phenomenon of *centering*.

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Role of Disulfide Pairing in the Biosynthesis of Antibody

The demonstration that the integrity of the disulfide bonds of rabbit antibody is essential for the maintenance of its immunologic specificity has directed our attention to the possible significance of disulfide formation during the biosynthesis of antibody. The relatively high cystine content of γ-globulin in general and of the immunologically active fragments from papain-treated rabbit antibody in particular means that the number of ways of pairing of half-cystines may be very large. A statistical calculation based on the assumption of variable pairing shows, for example, that there are 1.3×10^9 patterns of pairing for the formation of only four disulfides from 16 SH groups. The concept of variable pairing thus provides adequate scope for the broad spectrum of immunologic specificity. It is proposed that the nature of the antigenic group governs the particular pattern of pairing of the corresponding antibody and that this pattern is compatible with and serves to stabilize that conformation of the combining region which is complementary to the structure of the antigenic determinant. In addition to its possible immunological relevance, the notion of variable pairing provides a molecular basis for the explanation of the physical heterogeneity of γ-globulins.

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Problem of Specificity of Nuclear Differentiation in Rana pipiens

Previous work has shown that the majority of test embryos derived from late gastrula endoderm nuclear transfers exhibit a pattern of deficiencies consistent with the origin of the donor nuclei. In others the developmental deficiencies do not appear to conform to any specific pattern. To test whether these nuclear changes are *specific* for endoderm two additional types of analyses were carried out. In the first, test blastulae and gastrulae were joined in parabiosis with gastrula hosts obtained from normally fertilized eggs. In the second, at the time the parabiotic combinations were performed, chromosome preparations of the experimental embryos were made.

Since the deficient differentiation of the nuclear transplant embryos was not improved by parabiotic union with normal hosts, the nuclear condition responsible for these deficiencies appears to be intrinsic. The chromosomal analysis showed that embryos which *do not* conform to the endoderm pattern of deficiencies are aneuploid and therefore do not provide a valid test of the properties of the nuclei prior to transplantation. The valid cases for the significance of nuclear changes that accompany embryonic development are those in which the chromosome complement remains euploid following nuclear transfer, and these consistently exhibit the "endoderm" pattern of deficiencies. These results strengthen the case for specificity of nuclear differentiation but do not yet provide the final proof.

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A Hypothesis of the Pre- and Postsynaptic Sites of Action of Acetylcholine in Neurohumoral Transmission

As a neurohumoral transmitter, acetylcholine (ACh) is liberated by the axonal terminals of cholinergic fibers and activates the postsynaptic neuron. In certain non-neuronal tissues (cilia, smooth and cardiac muscle), ACh acts as a "local hormone," producing its effects on the same cells from which it is liberated. Several findings from our own and other laboratories are best explained by the assumption that ACh acts in both these capacities at cholinergic and certain non-cholinergic synaptic sites.

Cholinergic neurons contain high concentrations of acetylcholinesterase throughout their entire lengths; in adrenergic neurons the enzyme is scarcely detectable; concentrations are intermediate in others (for example, primary afferent neurons), the transmitters of which are unknown. Volle has found recently that intra-arterially injected ACh and carbamylcholine in the cat superior cervical ganglion probably activate presynaptic terminals, causing them to liberate ACh at the site of transmission. By DiCastro's procedure, Matsumura has established functional reinnervation of the cat superior cervical ganglion by the afferent vagal neurons and has obtained pharmacological and histochemical evidence that they liberate ACh in limited amounts. Our finding of acetylcholinesterase in the terminals of the cholinergically controlled hypothalamiconeurohypophyseal fibers, and the recent report from De Robertis' laboratory [*Endocrinol.* **66**, 741 (1960)] that these terminals contain two distinct populations of vesicles indicates that ACh is released, and in turn releases the hormones from the same terminals. The report of Burn and Rand [*Brit. J. Pharmacol.* **15**, 56 (1960)] of cholinergic involvement in the release of catecholamines by adrenergic fibers can be explained similarly.

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An Image Intensifier System for the Study of Rare Decay Modes of Elementary Particles

Filamentary chamber-image intensifier systems have been developed which yield pictures of charged particle tracks limited in spatial resolution only by the unit filament size, and which exhibit a time resolution of about 1 μsec. This device, used in conjunction with auxiliary particle counters, is well suited to the study of rare decay modes of elementary particles such as, for example, π- and K-mesons. The method employs a filamentary chamber divided into two or more regions. In one of the regions the incident mesons stop and subsequently decay. The other regions are traversed by the decay products. One face of the chamber is viewed by the image intensifier system and the opposite face is viewed by photomultiplier tubes, one for each of the separate chamber regions. It is required to trigger the image intensifier system that a counter telescope, including one of the chamber photomultipliers, indicates that a meson has stopped in the proper region, and also that appropriate delayed coincidences obtain between that stopping event and pulses from the other chamber photomultipliers which indicate the passage of a decay particle. Under these conditions the event is photographed and, in addition, the time sequence of the several counter outputs is available for recording. The system is capable of utilizing a large incident meson current and accepts decay product particles over a large solid angle. The counter selection procedure limits the number of photographs necessary to observe a given decay mode and facilitates the extraction of useful data from the photographs that are taken.

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Detection Thresholds: a Problem Reconsidered

W. P. Tanner and his collaborators have argued against thresholds playing a role in the detection of stimuli in a background of noise that makes them barely perceptible. Plots of the conditional probability of saying a stimulus is present when it is versus the probability of the same response when it is not are nonlinear as predicted by their threshold-free detection theory. By contrast, their version of a threshold model predicts it to be a line segment through (1,1), which is clearly rejected by the data. Two peculiarities of this model are pointed out. An alternative is suggested that overcomes them and that predicts the function to consist of a segment from (0,0) to (p,p') and another from (p,p') to (1,1). When compared with published data, this is as adequate as the prediction from the threshold-free model.

Consider now an experiment in which either noise alone, noise plus a tone of one frequency, or noise plus a tone of a different frequency is presented on a trial; the subject is required both to detect and to identify on each trial. If there is no detection threshold, the undetected responses should therefore exhibit differential identification; whereas, if there is a threshold, this would not be anticipated. Data from Elizabeth Shipley's thesis are presented which show no differential identification among the undetected responses, suggesting, but not proving, that detection thresholds exist.

The significance for psychophysical theory of this, as yet unresolved, question of thresholds is discussed.

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On Bird Species Diversity

The number of breeding bird species varies from habitat to habitat and from latitude to latitude. To understand the causes of this change, both bird censuses and a series of habitat diversity measures were taken in a wide variety of habitats and latitudes. Partial regression shows that (i) addition of new horizontal layers of vegetation increases bird species diversity, (ii) the three horizontal layers (0 to 2, 2 to 25, and over 25 feet) are about equally effective in controlling the number of bird species, and (iii) plant species diversity has no effect on bird species diversity except insofar as it affects foliage height diversity mentioned in (i).

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Preparation and Properties of Some New Derivatives of Silane and Disilane

Since silicon falls immediately below carbon in the periodic table, it is of interest to compare the properties of simple

silicon compounds with those of their carbon analogs. Substances containing $-SiH_3$ or $-SiH_2SiH_3$ groups may therefore be considered the silicon analogs of methyl and ethyl compounds respectively. Species containing these groups have been prepared and characterized in order to determine the effect of d_π-p_π bonding on their physical and chemical properties.

The synthesis of Si_2H_6 and of its partly substituted derivatives such as $CH_3SiH_2SiH_2CH_3$ has been carried out by means of a Wurtz-type reaction. Derivatives of Si_2H_6 such as SiH_3SiH_2I, $(SiH_3SiH_2)_2O$, $(SiH_3SiH_2)_2S$, $(SiH_3SiH_2)_3N$, and $(SiH_3SiH_2)_2NCH_3$ have been prepared, in addition to the completely methylated species $Si(CH_3)_3Si(CH_3)_2OH$, $[Si(CH_3)_3Si(CH_3)_2]_2O$, and $(CH_3)_3Si\text{-}O\text{-}Si(CH_3)_2\text{-}O\text{-}Si(CH_3)_2\text{-}Si(CH_3)_3$.

The compounds $SiH_3\text{-}O\text{-}CH_3$ and $SiH_3\text{-}S\text{-}CH_3$ have been synthesized from $[SiH_3N(CH_3)_3]I$ and CH_3OH or CH_3SH respectively. The base strength of $SiH_3\text{-}O\text{-}CH_3$ relative to $(SiH_3)_2O$ and $(CH_3)_2O$ has been investigated by means of its reaction with BF_3 and B_2H_6.

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The Growth Fraction: A New Concept Applied to Tumors

The possibility exists that, like the normal tissues from whence they arose, various tumors are mixtures of proliferating and nonproliferating cells. The Growth Fraction (G.F.) is suggested as an index of such mixtures and is defined as the ratio of proliferating cells (C_p) to total cells (C_t).

Mitotic figures represent a sample containing only proliferating cells. However, the bulk of proliferating cells are in interphase and as such are not distinguishable from nonproliferating cells. With very few exceptions, a second reliable indication of mitotic activity is the incorporation of thymidine into the nuclei of cells. After a brief exposure to tritiated thymidine and the subsequent passage of enough time to permit the cells to randomly distribute themselves in the mitotic cycle, the labeled cells can be identified on an autoradiograph. Within certain limits the following relationships should then apply (labels are marked with an asterisk):

$$\text{mitoses}^*/\text{mitoses} = C_p^*/C_p$$
$$\text{cells}^*/\text{cells} = C_p^*/C_t$$
$$\frac{\text{cells}^*/\text{cells}}{\text{mitoses}^*/\text{mitoses}} = \frac{C_p}{C_t} = \text{G.F.}$$

This formulation of Growth Fraction is potentially vulnerable to a number of technical and theoretical aberrations A sizable traffic of cells between the two populations would confuse the issue, and the assumption that the tumor can be represented by only two cell populations may be an oversimplification. Nevertheless the method as applied to spontaneous breast tumors growing in vivo in the C3H mouse indicates that the derived Growth Fraction is reasonably stable in any one tumor between the second and ninth days after injection of tritiated thymidine. In addition, a series of 14 tumors measured on the 5th day give a mean Growth Fraction of 0.61 (standard deviation of the mean, 0.029). Further studies attempting to confirm these results by an independent method are in progress.

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Protein Uptake by Pinocytosis in Amoebae

The uptake of macromolecular substances has been studied chiefly in free-living amoebae, but many observations on other cell types by electron microscopy suggest that the process is of wider significance. In amoebae, proteins which induce pinocytosis have been shown to be bound first to the cell surface before being taken up in vesicles. The mechanism of this initial binding reaction was studied by comparing the *p*H dependence of binding for two closely related proteins, ferritin and methylated ferritin. Ferritin behaves as a typical ampholyte, isoelectric at *p*H 4.4; methylated ferritin, in which carboxyl groups are blocked by esterification, is isoelectric at *p*H 6 to 7. Observations on living amoebae, confirmed by electron microscopy, demonstrated that binding depends upon net charge, the proteins being bound in the cationic form. The receptor substance on the cell surface, which other evidence suggested might be a mucopolysaccharide, was studied. Mass cultures of amoebae yielded after tryptic digestion a metachromatic, acidic polysaccharide.

Ferritin and methylated ferritin were also used for a study by electron microscopy of the changes which occur within the pinocytosis vesicle after uptake. The results show that there is no gross breakdown in the structure or function of the vesicle membrane: neither ferritin nor methylated ferritin particles escape through the membrane or pass into the microvesicles which are formed in great numbers from the primary vesicle. The evidence from this and other studies indicates that selective exchange mechanisms operate in both directions, between the vesicle and the surrounding cytoplasm. This conclusion leads to a clearer view of the relationship between pinocytosis and active transport at the molecular level.

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Hypothalamic Regulation of Luteinizing Hormone Secretion

Ovarian ascorbic acid depletion in rats pretreated with gonadotrophins was used as the assay for luteinizing hormone (LH). Mere insertion of an electrode into the median eminence was found to evoke hypophysial LH release, whereas passage of the electrode into the posterior hypothalamus had no effect. Lesions in the median eminence and in the suprachiasmatic region (the former inducing persistent diestrus and the latter constant vaginal estrus) prevented the rise in plasma LH which followed ovariectomy and were associated with subnormal values for hypophysial LH content. The rise in pituitary LH content which follows ovariectomy was prevented by the median eminence lesions but still occurred after suprachiasmatic lesions. Acid extracts of median eminence tissue from rat and rabbit evoked ascorbic acid depletion in the assay rats. Experiments with hypophysectomized assay rats showed that at least part of this activity of the extracts was caused by LH secretion. The activity could not be accounted for by the content of known pharmacological agents in the extract, such as vasopressin, oxytocin, histamine, serotonin, epinephrine, or substance P. The nature of the active material is unknown. Extracts from cerebral cortex were devoid of activity. It is suggested that a humoral agent, designated LH-releasing factor, secreted by the median eminence, regulates the secretion of LH by the adenohypophysis.

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Role of Corpus Callosum in Transfer of Visual Discriminations in the Cat

In the normal cat, visual discriminations learned with one eye are immediately transferred to the other eye by certain midline commissures passing between the two halves of the brain. The cat's visual apparatus includes a number of these midline commissures, such as the optic chiasm, the corpus callosum, and the posterior commissure. Sperry and his associates have shown that if both the optic chiasm and the corpus callosum are mid-sagittally sectioned in the cat, pattern discriminations fail to transfer from one eye to the other and the cat must relearn the pattern discrimination with the initially untrained eye. Complete transfer occurs between the eyes, however, if only one of these commissures is sectioned.

In testing brightness discrimination transfer, we have demonstrated that, in cats with the optic chiasm and the corpus callosum sectioned, simple suprathreshold brightness discriminations will transfer completely from one eye to the other as in normal cats. However, near-threshold brightness discriminations fail to transfer from one eye to the other as pattern discriminations also fail to transfer.

So far as tested, visual functions dependent upon the visual cortex (pattern and threshold brightness discriminations) require the corpus callosum for transfer from eye to eye when the optic chiasm has been sectioned; visual functions not dependent upon the visual cortex (suprathreshold brightness discriminations) do not require the corpus callosum for transfer.

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Initiation of Enzyme Formation by Birth

An earlier study of glycogen metabolism in mammalian liver unexpectedly revealed that glucose-6-phosphatase is absent in the fetus. Further examination of the liver showed that this enzyme appears first at term, increasing rapidly to adult levels immediately after birth. It seemed possible that all enzymes unique to liver and subserving special liver functions would have this same pattern of development in the mammal. Subsequent work in our laboratory and elsewhere has supported this idea.

We are now attempting to determine the factors initiating the formation of the unique liver enzymes after birth. Tryptophan pyrrolase was chosen as the subject of study. First, compounds known to increase enzyme activity in the adult liver such as substrate and adrenal cortical hormones were tested in the fetus. None of these compounds were able to stimulate enzyme formation in fetal liver and one would suppose they do not limit enzyme formation during fetal life. Secondly, the effect of birth and maturity on enzyme formation was studied by varying the gestation period. Tryptophan pyrrolase was studied in the rabbit, a species in which the gestation time can be shortened or lengthened by several days without interfering with growth or morphological development. Premature delivery resulted in an immediate and rapid increase in enzyme activity. Prolongation of the gestation time prevented enzyme formation until after delivery. Therefore, it would seem that some factor in the uterine environment represses formation of the unique liver enzymes.

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A Minute Chromosome in Human Chronic Granulocytic Leukemia

In seven cases thus far investigated (five males, two females), a minute chromosome has been observed replacing one of the four smallest autosomes in the chromosome complement of cells of chronic granulocytic leukemia cultured from peripheral blood. No abnormality was observed in the cells of four cases of *acute* granulocytic leukemia in adults or of six cases of acute leukemia in children. There have been several recent reports of chromosome abnormalities in a number of cases of human leukemia [including two of the seven cases reported here: Nowell and Hungerford, *J. Natl. Cancer Inst.* **25**, 85 (1960)], but no series has appeared in which there was a consistent change typical of a particular type of leukemia.

Cells of the five new cases were obtained from peripheral blood (and bone marrow in one instance), grown in culture for 24–72 hours, and processed for cytological examination by a recently developed air-drying technique (Moorhead, *et al., Exptl. Cell Research*, in press). The patients varied from asymptomatic untreated cases to extensively treated cases of several years' duration in terminal myeloblastic crisis. All seven individuals showed a similar minute chromosome, and none showed any other frequent or regular chromosome change. In most of the cases, cells with normal chromosomes were also observed. Thus, the minute is not a part of the normal chromosome constitution of such individuals.

The findings suggest a causal relationship between the chromosome abnormality observed and chronic granulocytic leukemia.

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Cytoplasmic Ribonucleic Acid Which Is Nucleolar and Nuclear Dependent and Its Relation to Amino Acid Incorporation

A comparative study has been made of the kinetics of nucleoside incorporation into ribonucleic acid of the nucleolus, extranucleolar portions of the nucleus, and cytoplasm of normal HeLa cells and cells in which the nucleolus is inactivated by means of localized ultraviolet microirradiation. Based on these studies, a model for RNA synthesis in actively growing cells is proposed in which (i) approximately two-thirds of the cytoplasmic RNA is synthesized in the nucleolus and the other one-third in the nucleus, and (ii) the nucleolar and nuclear RNA's are independent in their synthesis and movement to the cytoplasm.

A parallel study has been made of amino acid incorporation into normal and nucleolus-inactivated cells, and, in contrast to the above, no evidence of a significant nucleolar or nuclear dependence is found when the incorporation is followed for periods which are short compared to a cell generation time. These results support the belief that nucleoside and amino acid incorporation need not necessarily be simultaneous.

These experiments were carried out together with Prof. Maurice Errera while I was an American Cancer Society fellow in the laboratory of Prof. J. Brachet, Brussels.

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Chemically Induced Life-Shortening and Its Probable Genetic Basis

Exposure of animals, including man, to ionizing radiation results in acute effects and in such delayed effects as cancer appearing long afterwards, and life-shortening in general. The acute effects seem based in chromosomal damage. More recently, experiments with *Drosophila* have shown that life-shortening has a similar basis (Oster 1959, Ostertag and Muller, 1959). For such studies, appropriate stocks have been synthesized. Exposure of preimaginal stages that are soon followed, normally, by a period of intensive cell proliferation, growth, and differentiation leads to a relatively early onset of damage. Thus, death resulting shortly before or after eclosion, following treatment, probably represents a life-shortening comparable in principle to that observed in higher forms.

Since many carcinogenic chemicals possess other radiomimetic properties (for example, produce chromosomal breaks), it is essential to know whether they can also shorten the life-span otherwise than by causing cancer.

Stocks were made up containing chromosomes (ring-chromosomes) which allowed for normal functioning of the cells but which were more easily lost following breakage than normally structured chromosomes (rod-chromosomes). Untreated controls containing either type of chromosome had good survival rates (794/800) for the period studied, from larva to adult, while feeding nitrogen mustard to larvae resulted in lower survival (595/900) amongst the individuals containing the chromosomes which were more susceptible to induced damage than amongst those containing normal chromosomes (735/900). These results indicate that chemical carcinogens may cause premature "ageing" via the formation of chromosomal breaks and point to an especially insidious effect following contact with such chemicals.

This work was supported by National Institutes of Health grant CY-4615 Cl.

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Mechanical Properties of Blood Vessels and the Regulation of the Cardiovascular System

The mechanical properties of blood vessels determine their biological functions, that is, the dissipation and distribution of the mechanical energy produced by the heart and, therefore, the distribution of blood and blood flow.

These properties have historically been referred to by the entirely descriptive term "tone." We have recently been able, for the first time, to define analytically and evaluate quantitatively the parameters of tone, therefore making it possible to quantitatively analyze the biological effects upon the blood vessels of such things as the nervous and endocrine systems, aging, and disease. These mechanical properties are defined by the relationships between the force tending to cause vessel wall motion (stress) and the resulting motion (strain). Instantaneous radial stress (blood pressure) and strain (vessel diameter) from multiple sites in the vascular system have been recorded on magnetic tape and the data have been analyzed using digital or analog computers, or both. The properties of arteries which describe their "tone" can now be stated as a discrete equation whose terms can be evaluated. Moreover, since the so-called "pressure receptors" lying within blood vessel walls are really strain receptors, we have studied the interrelationship of blood pressure, vessel wall strain,

vessel wall mechanical properties, and the activity of nerve receptors lying in the vessel walls (for example, carotid sinus). It has been found that the mechanical properties of the receptor-containing vessels undergo reflex changes which suggest that the concept of blood pressure regulation as a physiological principal must be re-examined.

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Localization in Electron Microscopy of the Contractile Proteins of Striated Muscle by Antibody Staining

The contractile proteins, myosin and actin, as well as the digestion products of myosin, the meromyosins, have been localized in the striated muscle fibril by the fluorescent antibody technique at the level of the light microscope. It is desirable, however, to obtain localization at the level of the electron microscope. This would permit description of the distribution of individual protein species within the fine structure of the muscle filament. This might be extended to a study of the distribution of proteins in the relaxed and contracted states which should add to our understanding of the contractile apparatus. To this end three methods, of general applicability in electron microscopy, have been devised. (i) To increase electron scattering, mercury, in addition to fluorescein, was introduced into the antibody molecule. This permitted direct comparison between light and electron microscopy. (ii) Unmodified antibody was visualized in osmium-fixed material as a change in morphology due to the adherence of the antibody to the antigenic structures. (iii) Tissue stained with the unmodified antibody was extracted with solvents in which the combined antigen and antibody was selectively insoluble.

The results obtained from these three methods for electron microscopy are consistent with one another and with the results obtained by light microscopy. Higher resolution must be achieved, however, for more precise localization of individual proteins in muscle.

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Theory of Solid He^3

A theoretical analysis is given of the properties of solid He^3 on the basis of: (i) a gas-phase potential modified at small interatomic distances; (ii) a variational type wave function constructed from a properly antisymmetrized product of individual atom orbitals localized on the various lattice points; (iii) a Dirac vector model to describe the symmetry energy with an exchange integral deduced from (i) and (ii); (iv) a spin-wave and a Kramers-Opechowski approximation at "low" and "high" temperatures respectively for a calculation of the free energy of the nuclear spins; and (v) a Debye phonon model for the description of the vibrationally excited states of the solid. On this basis, calculated values at low pressures and temperatures ($p \approx 30$ atm; $T \leqq 1°K$) are presented for: (i) the cohesive energy; (ii) the root mean square deviation of the atom from its lattice site; (iii) the nuclear magnetic susceptibility which corresponds to an antiferromagnetic behavior with Curie temperature T_C; (iv) the variation (decrease) of T_C with increasing pressure corresponding to a possible nuclear antiferromagnetic to nuclear ferromagnetic transition at high pressures; (v) the specific heat which exhibits an anomaly at $T \approx T_C$ associated with the alignment of the nuclear spins; (vi) the thermal expansion coefficient which becomes negative below about 0.5°K; (vii) the melting curve which is characterized by a minimum, and, in addition, if liquid He^3 never becomes a superfluid, by a maximum; (viii) certain properties of solidified isotopic mixtures of He^3 and He^4. Comparison of the theory is made with available data.

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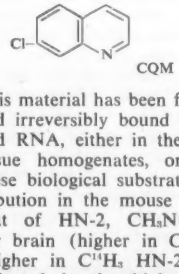
Mechanism of Biological Alkylations

In spite of the interesting and important variety of biological effects of polyfunctional alkylating agents, the amazing spectrum of compounds possessing similar biological and clinical activities, and the many investigations of the mechanism of action of these compounds, many of the most important details of their mode of action remain obscure.

As one part of our studies of this problem, we have prepared chloroquine mustard (CQM) labeled with tritium in the quinoline nucleus.



CQM

This material has been found to be rapidly and irreversibly bound by protein, DNA, and RNA, either in the intact animal, in tissue homogenates, or in solutions of these biological substrates. The tissue distribution in the mouse is very similar to that of HN-2, $CH_3N(C_2H_4Cl)_2$, except for brain (higher in CQM) and kidney (higher in $C^{14}H_3$ HN-2). The former is reflected in the higher central nervous system toxicity of CQM; the latter, in the demethylating function of the liver.

In reaction with DNA ($10^{-2}M$ in phosphorus), less than 2 percent of $10^{-4}M$ CQM was extractable by chloroform, even after 20 minutes at 90°C. In reaction with RNA ($3 \times 10^{-2}M$), 18.5 percent was extractable without hydrolysis at 90°C. For bovine serum albumin ($10^{-4}M$) only 1.5 percent was extractable before hydrolysis at 90°C, 15 percent after. In contrast, reaction of CQM in water in the absence of biological substrate gave 32 percent extractable before heating to 90°C, an additional 54 percent after.

With larger equivalents of CQM, over 2 moles of the alkylating agent were bound per nucleotide unit of DNA. Most of the bound CQM reacted without liberation of acid and was not freed by hot alkaline hydrolysis (less than 5 percent chloroform-extractable). This would indicate that most of the binding has occurred through the tertiary ring nitrogen atoms of DNA, rather than through hydroxyl, amino, or phosphate oxygen groups.

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WILLIAM J. STEELE

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Neurological Basis of Behavior in the Cat

Recent findings indicate the brain is served by two sensory systems. The first system includes the several specific pathways which selectively subserve vision, audition, skin sense and joint-muscle sense, each of which shows an exquisite degree of anatomical and physiological localization. The second system, called nonspecific, is much less localized in function and provides areas of interaction of many sensory modalities from many parts of the body. These lie in the reticular formation of the brainstem and are believed to be the sites of integration of neural processes which form the basis of adaptive behavior. That this hypothesis must be seriously questioned is seen from the following experiments. Lesions were placed in the upper midbrain so as to interrupt most of the specific sensory pathways, leaving intact most of the reticular formation. Such animals become automata, characterized by stereotyped, restless behavior, in which there is little or no vestige of their preoperative personalities. They are mute and without facial expression. There is great deficit of attention and their response to visual, auditory, tactile, and painful stimuli is largely generalized activation. They show little or no rage, fear or pleasure responses, somatic or autonomic. Social and sexual relations with other animals are virtually lacking. Thus, when the forebrain is deprived of sensory information via the specific pathways, the remaining portions of the nervous system including the reticular formation are unable to maintain the repertoire of attentive, affective, and adaptive behavior.

J. M. SPRAGUE
ELIOT STELLAR
W. W. CHAMBERS

School of Medicine,
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Appearance of Discretely Sedimenting Components in Deoxyribonucleic Acid above pH 9

When calf thymus, salmon sperm, and bacteriophage deoxyribonucleic acids are studied in the ultracentrifuge at *p*H values above 9 at low concentrations (below 0.01 percent), the continuous distribution of sedimentation coefficients seen at lower *p*H values changes dramatically. Several

extremely sharp and discretely sedimenting components are seen by both ultraviolet and schlieren optics. The multiple components behave in a normal manner; the log x versus t plots are straight. The transition from a continuum distribution to a number of discrete components occurs progressively over a *p*H range of about ½ a *p*H unit, starting at *p*H 8.8. The effect is completely reversible and no denaturation of the DNA occurs. In spite of the dramatic change in the distribution of sedimentation coefficients, the change in viscosity is not great. The resolution of discrete components requires some convective disturbance; a superimposed density gradient (for example, sucrose) prevents the formation of the discrete components although considerable sharpening of the pattern occurs. At low ionic strengths, (0.007), the discrete components are present until the speed of the ultracentrifuge is lowered to 15,000 rev/min. At higher ionic strengths, (0.1), the speed must be reduced to 40,000 rev/min before reproducible results are obtained, probably due to the formation of a salt density gradient at higher speeds. The number of discrete components is a sensitive function of the DNA concentration from 0.001 to 0.01 percent. The effects of deoxyribonuclease and chymotrypsin on the discrete components have been studied. These results will be discussed with reference to the significance of the polydispersity of DNA as seen in the ultracentrifuge.

VERNE N. SCHUMAKER
School of Medicine,
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Discriminative Classical Conditioning under Curare Can Later Control Discriminative Avoidance Responses in the Normal State

Dogs were trained to avoid shock in response to a signal. The avoidance response was the pressing of a panel, the signal (S^0) was a light going out, the shock was of 4 ma intensity (applied to the hind toe pads), and the time interval between signal onset and shock onset was 10 sec. If the correct response occurred during the time interval between signal onset and the usual shock presentation time, no shock was given and the signal was terminated. Intertrial intervals were varied systematically, with a mean of 1.5 min.

After the dogs were reliably pressing the panel in response to the signal, with response latencies of 3 sec or shorter, they were totally curarized. While the dogs were completely immobilized under curare, a Pavlovian discriminative conditioning session was carried out. A new signal (S^+) was consistently paired with shock, using a delayed procedure and a time interval of 10 sec between S^+ onset and shock onset. The shock duration was 5 sec. On some trials a contrasting signal (S^-) was presented for 15 sec, but it was not paired with shock. A sequence of 99 discriminative conditioning trials was presented, ending with an S^+ trial. The S^+ and S^- trials were partly randomized in a special sequence. After this conditioning session, the dogs were given 48 hours to recover from the various physiological effects of curarization. Next they were returned to the training situation in the normal, undrugged state, and the three previously used stimuli (S^0, S^+ and S^-) were presented. The latency of panel-pressing responses was recorded during these tests of the efficacy of the three stimuli.

The dogs responded in a way consistent with their discriminative Pavlovian conditioning experience. There were frequent panel presses in response to S^0 and S^+, very few in response to S^-. When a dog pressed a panel in the presence of S^-, the latency of the response was often long.

RICHARD L. SOLOMON
University of Pennsylvania
LUCILLE H. TURNER
Harvard University

Mechanisms of Bile Acid Formation

The cleavage and oxidation of the cholesterol side-chain which takes place in liver mitochondria requires, in addition to ATP, AMP, DPN, Mg^{++}, and boiled supernatant factor, supplementation with gluthathione and citrate or malate. A requirement for TPNH can also be demonstrated when the mitochondria are pretreated by extraction with potassium chloride solution. The boiled supernatant factor is obtained in most active form only if the microsomes are removed before boiling. Experiments with C_{26}- as well as C_{25}- and C_{27}- labelled cholesterol indicate that all three terminal carbon atoms can be oxidized to carbon dioxide by this system. Small yields of labelled acetone can be obtained from such systems; carbons 26 or 27 of cholesterol are converted to methyl carbons of acetone while carbon 25 becomes the carbonyl group of acetone.

The identification of acetone as a cleavage product is somewhat surprising in view of the findings by Bergstrom and his group, as well as by our own laboratory, that trihydroxycoprostanoic acid is efficiently converted to cholic acid. Experiments in our laboratory with trihydroxycoprostane have shown that the terminal carbon atoms of this sterol are more readily converted to carbon dioxide than is cholesterol in the rat liver system. Furthermore, additional experiments have demonstrated that trihydroxycoprostane is readily converted by rat liver homogenates to trihydroxycoprostanic acid, a naturally occurring reptilian bile acid, and that this acid is subsequently converted to cholic acid and carbon dioxide. If the latter pathway is eventually found to be a major metabolic route to cholic acid, then the production of acetone must be considered a minor pathway representing a relatively nonspecific action of an oxidase upon cholesterol and trihydroxycoprostane.

EZRA STAPLE
MICHAEL W. WHITEHOUSE
HELGA M. SULD, SAMUEL GUREIN
School of Medicine,
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Estimating the Forces of the Human Heart: Their Diminution as Age Advances and before Disease Develops

Studies on the cardiac forces made during recent years in this laboratory have taken three directions. (i) In mathematical studies, Noordergraaf, working both in Philadelphia and in Utrecht, Holland, using data on blood pressure and elasticity of vessels throughout the body, has calculated the movement of the body's center of gravity at each instant during the cardiac cycle. The forces resulting from this movement correspond closely in magnitude and time with those recorded from the body by the "force" ballistocardiograph. (ii) In experiments (with Schnabel and Mayock) systole was simulated in fresh cadavers in such a manner that the initial "cardiac" forces could be computed. Good agreement was found between the magnitude of these forces and the forces of reaction recorded by the "force" ballistocardiograph. (iii) In empirical studies (with Hildreth and Wood) 200 persons, originally healthy, have been followed for 17 years or longer after their first ballistocardiograms. Cardiac forces diminish as age advances even though health is maintained; from the regression of this normal relationship a "physiological age" for the heart of any subject can be computed from his ballistocardiogram. In our series, the group who later developed coronary heart disease exhibited at the initial test cardiac forces significantly smaller for their age than normal; before clinical manifestations appeared, their hearts behaved like those of much older persons.

ISAAC STARR
School of Medicine,
University of Pennsylvania

Direct Measurement of Deoxyribonucleic Acid Content of Genetic Loci in Drosophila

The giant chromosomes of the Diptera provide a unique material for direct measurement of the deoxyribonucleic acid (DNA) content of discrete chromosomal regions (the bands) by the use of microspectrophotometric methods. It is known that individual genetic loci are represented in the giant chromosomes by characteristic cross bands, highly differentiated from each other in their structure. They range from single lines through pairs of lines ("doublets") to quite complex patterns. A study of the distribution of DNA content in the various types of band in *Drosophila melanogaster* carried out earlier in this laboratory showed a variation ranging over 2 to 3 logarithmic units, the distribution of quantities for single and double bands overlapping. A calculation of the number of nucleotide pairs contained in a minimal unit resolvable by the ultraviolet microscope, with appropriate assumptions with regard to polyteny, leads to the order of magnitude of 50,000 nucleotide pairs, a result consonant with current measurements of DNA molecular weight. This would be the maximal DNA content for a single locus.

The critical assumption involved in the calculation is that the number of replications leading to polyteny is the same for all loci. This has been tested as follows: Feeding of larvae for the first 24 hours after hatching on a medium containing tritiated thymidine is followed by transferral to a standard medium. Microspectrophotometric measurements of DNA in the fully grown chromosomes (total DNA synthesized) are followed by autoradiographic measurements of thymidine incorporation in the same chromosome region (DNA synthesized during the early replications). If replications during development are equivalent at the different loci, the ratio of grain count to total DNA should be constant throughout a chromosome. Preliminary data indicate disproportionately high (twofold) early synthesis for certain regions, which form puffs during the much later prepupal period. The result may eventually be of considerable importance for discussions of nuclear differentiation. In the single bands used for the calculation given above such a twofold disproportionate synthesis could have reduced the calculated value to 25,000 nucleotide pairs.

This work was aided by grant C-1613 from the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service, and by an institutional grant from the American Cancer Society.

JACK SCHULTZ
GEORGE T. RUDKIN
Institute for Cancer Research

Cytological Evidence for the Nature of Action of Hooded Gene in Barley

The dominant gene hooded in barley replaces the awns of the lemmas with a complex structure consisting of two lemma-like bodies superimposed end to end, the lower one oriented inversely. It usually produces a palea and floral organs, which may be rudimentary or well developed, depending upon gene expression. The apical "lemma" may be much reduced, or narrowed to an awnlike structure, but when well developed it also produces a palea and rudimentary floral organs. The two "lemmas" of the hood are connected by a rachiola-like structure, which represents an "island" of axis tissue, completely separated from the remainder of the floral axis by tissue of the original lemma, an appendage. In ontogeny, the first evidence of hood production is a swelling on the adaxial side of the young lemma primordium. In cross section, this swelling shows an epidermal layer with much smaller, more actively dividing cells than the corresponding layer in the awned genotype. The subepidermal cells are larger, but they differ from corresponding cells of awned in their planes of division. Immediately above the procambial strand of this swelling is a layer of cells bearing starch inclusions, which is lacking in awned. Thus histological structure and cell behavior resemble that of the young floral axis. Evidence from estimates of nuclear and cell size in developing organs of various ages suggests that the phenomena described are associated with differential rates of synthesis of nuclear and cytoplasmic material.

G. LEDYARD STEBBINS
University of California, Davis

Temperature Dependence of Thermal Inactivation Rates at Very High Temperatures

The theory of absolute reaction rates predicts the temperature dependence of thermal inactivation rate constants for biological materials. However, theory and experiment have been compared only over a limited temperature range because of the experimental difficulties of heating and cooling materials rapidly. We have developed an instrument which allows liquid suspensions to be heated or cooled in times comparable to 1 msec and permits exposure to thermal square waves of amplitudes between 30° and 100°C, and durations between 10 msec and 100 sec.

In this instrument the pistons of three large syringes holding, respectively, the test suspension at a noninjurious temperature, hot buffer, and cold buffer, are coupled together and driven mechanically. The test fluid and the hot buffer are driven into a mixing chamber, thereby establishing an equilibrium temperature. The output from the mixing chamber is driven at a predetermined speed through a flow tube of variable length that is held at the equilibrium temperature. This output is mixed in a second chamber with the cold buffer, thereby suddenly cooling the test material.

We have studied the thermal inactivation of haploid yeast by manual techniques in the temperature range from 48° to 58°C, and by our instrument, from 56° to 74°C. The experimental temperature dependence agrees well with theory over the entire range studied. This instrument is used to study a variety of phenomena, in which reactions are started and subsequently stopped before assay.

THOMAS H. WOOD
University of Pennsylvania

Intercellular Transfer of Hemolysin

Intercellular transfer of rabbit antisheep hemolysin has been used as a relative inverse measure of avidity of the hemolysin-cell union. The percent transfer was determined in 50 percent units by adding unsensitized Cr^{51}-labeled red cells to sensitized unlabeled red cells and ascertaining the percent Cr^{51}-cell lysis after adding complement. In previous work [W. H. Taliaferro, L. G. Taliaferro, Pizzi, *J. Infectious Diseases* **105**, 197 (1959)], we studied the gamma-1 Forssman hemolysin of large molecular weight which occurs in normal rabbit serums and in immune serums after one antigen injection or reinjection [Stelos and Taliaferro, *Anal. Chem.* **31**, 845 (1959)]. This gamma-1 hemolysin in both normal and immune serums was composed of a nonavid component which transferred rapidly within 10 minutes and an avid component which transferred much more slowly. Immune serums collected one week or more after the injection of antigen were progressively more avid. In the present work, we used immune serums from rabbits repeatedly immunized until they contained not only the gamma-1 Forssman hemolysin but also the gamma-2 Forssman hemolysin of smaller molecular size. We found that the latter transferred more rapidly than the former. Thus, as the gamma-1 hemolysin decreased and the gamma-2 hemolysin increased during immunization, the percent intercellular transfer increased, that is, avidity decreased. The avidity of the gamma-2 fraction was intermediate between normal gamma-1 and immune gamma-1 hemolysin.

This work was performed under the auspices of the U.S. Atomic Energy Commission.

WILLIAM H. TALIAFERRO
LUCY GRAVES TALIAFERRO
Argonne National Laboratory

Investigation of Disease Resistance and the Mathematical Problem of Patterns

The investigation of innate resistance to diseases both of infectious and noninfectious nature (including such maladies as gout, arthritis, coronary disease, cancer, mental disease, alcoholism, and so forth) holds great promise but has been hampered by two main obstacles. First, sufficient detailed data of the right sort are not available and are difficult to collect. These data should include measurements of those inborn anatomical, physiological, and biochemical characteristics of individuals which are pertinent to the disease under consideration. The delineation between innate and adaptive characteristics has received little attention and is not always easy; the selection of those characteristics which are pertinent to a particular disease may likewise be difficult.

Further progress has been made in our attempts to collect data related to susceptibility to alcoholism, but an additional obstacle has been encountered in the existence of confusing interethnic differences which need to be taken into account but are difficult to interpret.

A second most basic obstacle to the investigation of innate susceptibilities is the lack of suitable mathematical techniques whereby the *patterns* of different individuals can be recognized, compared, and contrasted in a quantitative manner. Only recently have mathematicians become interested in problems which are related significantly to this basic obstacle.

The lack of these fundamental techniques has been and continues to be a serious deterrent to the laborious collection of the vast amount of data which will be essential before disease susceptibilities and resistances can be adequately investigated. The handling of such data will necessarily entail the use of high-speed computers.

ROGER J. WILLIAMS
University of Texas

Learning and Problem-Solution in the Marmoset

Comparative studies of the learning and problem-solution ability of the marmoset have been carried out in the light of existing data on the rat and the rhesus monkey. The marmoset is the most primitive of the simian primates. While its brain has typical primate conformation, it is not as developed as that of the rhesus monkey, its cerebral cortex, for example, being virtually smooth. Given the marmoset's intermediate phylogenetic status, and particularly its intermediate position in neurological development, the experimental question is to determine its relative behavioral capacities. To this end, marmosets were trained to displace the correct one of two or more stimulus-objects to find food. In simple discrimination learning, requiring consistent response to a specific stimulus, the rat, marmoset, and rhesus monkey all perform at about the same level. Where the tests require discrimination on the basis of symbolic process (delayed reaction) or general principle (learning set and oddity problems), the rat fails almost completely and the rhesus monkey succeeds to a high degree. The marmoset performs at very close to the level of the rhesus monkey. Analysis of errors in these tests shows that the rat is very much stimulus-bound in its behavior whereas the marmoset, like the rhesus monkey, can go beyond simple, stimulus-response habits and solve problems on the basis of symbols and general principles.

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Association Affairs

Programs Planned for the AAAS New York Meeting

Section and society programs in the medical sciences, dentistry, and pharmacy and in the history and philosophy of science to be presented at the New York meeting are given here. Programs in mathematics, physics, chemistry, astronomy, geology and geography, the biological sciences, anthropology, psychology, and the social and economic sciences have been previously announced [*Science* **132**, 1259 (28 Oct. 1960); **132**, 1318 (4 Nov. 1960); **132**, 1403 (11 Nov. 1960)].

Medical Sciences

Section N. Five-session symposium, cosponsored by the American Physiological Society and the Society of General Physiologists: "Biophysics of Physiological and Pharmacological Actions," arranged by Abraham M. Shanes, National Institutes of Health; 26–28 Dec.

Part I: "Elementary Systems," with T. Shedlovsky, Rockefeller Institute, presiding; 26 Dec. After an introduction by Shanes, papers will be presented on mechanisms of active cation transport (Joseph F. Hoffman, National Heart Institute); ion transport across the erythrocyte membrane (R. L. Post, Vanderbilt University School of Medicine); electrogenesis in frog skin (T. Hoshiko, Western Reserve University School of Medicine); the interaction of drugs with model systems (Norman L. Gershfeld, National Institutes of Health).

Part II: "Nerve," with K. S. Cole, National Institutes of Health, presiding; 26 Dec. Papers will be presented on nerve structure (J. D. Robertson, McLean Hospital, Boston); ionic movements in nerve fibers at rest and during recovery (W. P. Hurlbut, Rockefeller Institute); ionic permeability changes underlying nerve excitation (F. A. Dodge, Rockefeller Institute); spike generation and sodium ions (K. Koketsu, University of Illinois College of Medicine); possible mechanisms underlying the production of after-potentials in nerve fibers (J. M. Ritchie, Albert Einstein School of Medicine); energetics of activity (B. C. Abbott, University of California, Los Angeles); metabolism in relation to function in nerve cells as illustrated by an excised sympathetic ganglion (M. G. Larrabee, Johns Hopkins University).

Part III: "Muscle I: Membrane Properties," with Alexander Sandow, Institute for Muscle Diseases, presiding; 27 Dec. Papers will be presented on the influence of ions on the membrane potential of muscle fibers (P. Horowicz, Washington University School of Medicine); ion fluxes (R. Swan, Cornell University Medical College); potassium movement in muscle membrane — anomalous rectification (W. Freygang, National Institutes of Health); electrical activity of skeletal muscle (Gertrude Falk, University of Washington); calcium movements in striated muscle during contraction, and contractures with or without membrane depolarization (C. Paul Bianchi, Institute for Muscle Disease); the role of extracellular calcium ions in excitation-contraction coupling in skeletal muscle (George B. Frank, University of Manitoba, Winnipeg, Canada); correlation of calcium uptake and contractility in frog rectus abdominis muscle (Abraham M. Shanes); "relaxation response" of tonic muscle fibers (William G. Van der Kloot, New York University School of Medicine).

Part IV: "Muscle II: Contractile Properties," with Wallace O. Fenn, University of Rochester Medical School, presiding; 27 Dec. The first paper will be the vice-presidential address of Section N, "The Mode of Action of Drugs," by Carl F. Schmidt, University of Pennsylvania. After the address, the 16th Theobald Smith Award, given by Eli Lilly and Company, will be presented. Papers will then be presented on structure and function of twitch and slow striated muscle fibers (Lee D. Peachey, Columbia University); general energetics of contraction (Alexander Sandow); the immediate energy source for contraction of muscle (R. E. Davies and D. F. Cain, University of Pennsylvania); the nature of the contractile mechanism in muscle (R. J. Podolsky, Naval Medical Research Institute); general physiology and pharmacology of junctional transmission (Harry Grundfest, Columbia University).

Part V: "Muscle III," with C. Ladd Prosser, University of Illinois, presiding; 28 Dec. Papers will be presented on some current theories and problems in cardiac electrophysiology (B. Hoffman, New York Downstate Medical Center); possible electrochemical factors in heart electrophysiology (J. W. Woodbury, University of Washington School of Medicine); electrolyte metabolism in myocardial tissue (W. C. Holland, University of Mississippi Medical Center); electrochemistry of smooth muscle and its relationship to contraction (L. Hurwitz, Vanderbilt University School of Medicine); potassium and the mechanical responsiveness of artery strips (L. Barr, University of Michigan School of Medicine); electrolytes and contraction in cardiac muscle (Saul Winegrad, National Institutes of Health).

Section N is a cosponsor of the following symposia: "Fundamentals of Keratinization," program of Section Nd–Dentistry, 30 Dec. (see Section Nd), and "Career Opportunities in Medicine and Dentistry," program of Alpha Epsilon Delta, 29 Dec.

Attention is called to the three-session symposium of the New York Academy of Sciences, "Current Problems in Electrobiology," on 30 Dec. (for details, see the program of the Academy).

Alpha Epsilon Delta. Symposium cosponsored by Sections C–Chemistry, F–Zoological Sciences, N–Medical Sciences, Nd–Dentistry, and Beta Beta Beta Biological Society: "Career Opportunities in Medicine and Dentistry," arranged by Maurice L. Moore, national secretary, Alpha Epsilon Delta, with Charles V. Reichart, national treasurer, Alpha Epsilon Delta, presiding; 29 Dec. After introductory remarks by Reichart, papers will be presented on physician needs for the future (William H. Stewart, U.S. Department of Health, Education, and Welfare) and on dentist needs for the future (Shailer Peterson, Council on Dental Education, American Dental Association). There will then be a panel discussion on opportunities in dentistry, with Raymond J. Nagle, New York University College of Dentistry, as moderator, and a panel discussion on opportunities in medicine, with James O. Pinkston, Downstate Medical Center, State University of New York, as moderator.

Luncheon and address: "The Doctors' Dilemma," by I. S. Ravdin, vice-president for Medical Affairs; 29 Dec. Conferences with admissions officials and visits to medical and dental schools will follow the luncheon and address. All persons interested in premedical and predental education are invited to attend the program of 29 Dec. and the luncheon.

American Medical Association, Committee on Cosmetics. Two-session symposium, cosponsored by Section Np–Pharmacy: "The Scientist's Contribution to the Safe Use of Cosmetics," arranged by Joseph B. Jerome, Committee on Cosmetics, with Marion B. Sulzberger, New York University, presiding; 29 Dec.

Part I: After an introductory statement by Marion Sulzberger, papers will be presented on some problems of biological research and their relation to cosmetic development and use (William Montagna, Brown University); new methods for the study of percutaneous absorption (Kenneth M. Wilson, Army Chemical Center); radioisotopes in cosmetic research (William Bousquet, Purdue University); dermatologic research and cosmetic formulation (Allan L. Lorincz, University of Chicago); the science of safe cosmetic formulation (Glen J. Sperandio, Purdue University). There will be a panel discussion after presentation of the papers.

Part II: Papers will be presented on the clinical dermatologist and cosmetic reactions (Howard T. Behrman, New York Medical College); methods of appraisal for potential hazard (Adolph Rostenberg, University of Illinois); industry's interest and responsibility in cosmetic safety (Willard M. Bright, Lever Brothers Company); the government's role in the control of cosmetics (Irvin Kerlan, Food and Drug Administration. There will be a panel discussion after the presentation of the papers.

American Psychiatric Association. Five-session symposium, program of the Committee on Research of the American Psychiatric Association, cosponsored by Section I–Psychology and the American Psychoanalytic Association: "Expression of the Emotions in Man," arranged by Peter H. Knapp, Boston University School of Medicine; 29 and 30 Dec.

Part I: Introductory session, with Henry W. Brosin, University of Pittsburgh, presiding; 29 Dec. After an introduction by Knapp, a paper on the phylogenetic and neurophysiologic aspects will be presented by Paul D. MacLean (National Institute of Mental Health) and discussed by Stewart Wolf (University of Oklahoma Medical Center). A paper on the ontogenetic aspects will be presented by Rene A. Spitz (University of Colorado Medical Center) and discussed by Sibylle K. Escalona (Albert Einstein College of Medicine).

Part II: "Methods of Study," with Robert A. Cohen, National Institute of Mental Health, presiding; 29 Dec. A film, *Entering the Mind through the Sensory Gateways*, will be presented by Felix Deutsch, Boston University School of Medicine and the Boston Psychoanalytic Society and Institute; this will be followed by a panel discussion, "Lexical and Linguistic Levels," in which the main presentation will be by George F. Mahl, Yale University School of Medicine.

Part III: "Methods of Study," with Morton F. Reiser, Albert Einstein College of Medicine, presiding; 29 Dec. There will be a panel discussion, "Kinesic and Visceral Levels," in which the main presentations will be by Ray L. Birdwhistell, Temple University Medical Center, and John I. Lacey, Fels Research Institute, Antioch College.

Part IV: "Synthesis and Critique of Methods"; 30 Dec. Papers presented will be "The Viewpoint of the Social Scientist" (Gregory Bateson, Stanford University), which will be discussed by Karl H. Pribram, Stanford University; "The Viewpoint of the Experimentalist" (Harry F. Harlow, University of Wisconsin); and "The Viewpoint of the Psychoanalyst" (Kenneth M. Colby, San Francisco Psychoanalytic Society).

Part V: Closing session, 30 Dec. Papers presented will be "Toward a Classification of Affects" (George L. Engel, University of Rochester School of Medicine), which will be discussed by Samuel Novey, Baltimore, and "Emotions in the Perspective of Evolutionary Theory" (David A. Hamburg, National Institute of Mental Health), which will be discussed by Margaret Mead, American Museum of Natural History.

New York Academy of Sciences. Three-session conference on "Current Problems in Electrobiology," with Robert L. Kroc, Section of Biological and Medical Sciences, New York Academy of Sciences, as conference chairman; 30 Dec. The conference will begin with greetings from the Academy by Kroc.

The chairman for Session I will be Abraham M. Shanes, National Institutes of Health. Papers will be presented on ultrastructure of excitable membranes (J. D. Robertson, University College, London, England); macromolecular properties of excitable membranes (L. J. Mullins, Purdue University); ionic mechanisms in electrogenesis (Harry Grundfest, Columbia University).

The chairman for Session II will be Harry Grundfest. Papers will be presented on modes of operation of electric organs (M. V. L. Bennett, Columbia University); activation and inactivation in a nerve ending (W. R. Loewenstein, Columbia University); nervous control of chemical sensitivity in muscle (S. Thesleff, University of Lund, Stockholm); spike potential of spinal motoneurons (C. A. Terzuolo, University of Minnesota).

The chairman for Session III will be H. H. Jasper, Montreal Neurological Institute, McGill University. Papers will be presented on the organization of cortex with respect to its afferent supply (G. H. Bishop, Washington University); electrophysiological properties of an archicortical neuron (E. R. Kandel, Massachusetts Mental Health Center); analysis of cortical axodendritic synaptic organizations (D. P. Purpura, Columbia University).

The Academy will have a luncheon, cocktail hour, and informal subscription dinner on 30 Dec.

Attention is called to the five-session symposium of Section N, "Biophysics of Physiological and Pharmacological Actions," 26–28 Dec. (for details, see Section N, above).

Dentistry

Section Nd. Two-session symposium, cosponsored by Section N–Medical Sciences, the American College of Dentists, the American Dental Association, and the International Association for Dental Research, North American Division: "Fundamentals of Keratinization," arranged by Earl O. Butcher, College of Dentistry, New York University; 30 Dec.

Butcher will preside over Session I, in which papers will be presented on the mechanism of keratinization (A. Gedeon Matoltsy, University of Miami); the histochemical distribution of sulfhydryls and disulfides in vertebrate keratins (R. J. Barrnett, Yale University School of Medicine, and Reidar F. Sognnaes, School of Dentistry, University of California, Los Angeles); keratinization of whole skin and isolated epidermis in vitro (George Szabo, Harvard Medical School); keratinization as seen with the electron microscope (J. A. Rhodin and E. J. Reith, New York University School of Medicine); the effects of vitamin A on keratinizing epithelia (Howard A. Bern and Donald J. Lawrence, Cancer Research Genetics Laboratory, University of California, Berkeley); effects of vitamin A on keratinization in the vitamin-A-deficient rat (J. P. Parnell and B. Sherman, Downstate Medical Center, State University of New York).

Sognnaes will preside over Session II. Papers will be presented on the effect of environment on the physical characteristics of the cornified epithelium (Irvin H. Blank, Harvard Medical School); keratinization of the oral mucosa (Julia Meyer, College of Dentistry, University of Illinois); keratinization in dental cysts (Jens J. Pindborg, Royal Dental College, Copenhagen); the extracellular position of enamel (M. L. Watson, University of Rochester); the chemistry of the protein matrix of enamel (K. A. Piez, National Institutes of Health).

Pharmacy

Section Np. There will be opening remarks by John E. Christian, secretary of Section Np, and this will be followed by greetings from the American Society of Hospital Pharmacists, the American Pharmaceutical Association, the New York State Council of Hospital Pharmacists, and the American Hospital Association.

There will be two sessions for contributed papers in hospital pharmacy, arranged by George F. Archambault, Division of Hospitals, U.S. Public Health Service, and Joseph A. Oddis, American Society of Hospital Pharmacists and American Pharmaceutical Association; 27 Dec. Oddis will preside over Session I; Archambault, over Session II.

On the same day there will be a luncheon, arranged by E. R. Squibb and Sons, New York (coordinated by P. A. Freeman), and the vice-presidential address of Section Np, "Dedication to Pharmacy," given by Joseph V. Swintosky.

On 27 Dec. there will also be programs arranged by Wyeth Laboratories, Philadelphia (coordinated by H. L. Ferrier), and by McKesson and Robbins, Inc., New York (coordinated by Milton N. Stamatos.

There will be two sessions for contributed papers, arranged by John E. Christian. John Autian (University of Texas) will preside over one of these, on 29 Dec.; Lee H. MacDonald (Upjohn Company, Kàlamazoo, Mich.) will preside over the other, on 30 Dec.

The entire program of Section Np is cosponsored by the American Association of Colleges of Pharmacy, the American College of Apothecaries, the American Pharmaceutical Association, the American Society of Hospital Pharmacists, and the National Association of Boards of Pharmacy.

History and Philosophy of Science

Section L. Commemorative two-session symposium honoring Robert C. Watson, commissioner, U.S. Patent Office, cosponsored by the Society for the History of Technology: "Patents in the Advancement of Knowledge," arranged by John W. Streeter, secretary of Section L; 30 Dec. J. William Hinckley, president, Research Corporation, New York, will preside over Part I. Speakers will be Jacob Rabinow, president, Rabinow Engineering Company, Richard P. McGrail, American Cancer Society, and Johan Bjorksten, Bjorksten Research Laboratories. Robert L. Johnson, Temple University, will preside over Part II. Speakers will be Fritz Machlup, Princeton University, Berj Hagopian, Transval Electronics Corporation, and Charles C. Price, University of Pennsylvania. Rudolph F. Bannow, National Association of Manufacturers, will introduce Watson.

The vice-presidential address of Section L will be given on 30 Dec., with Melvin Kranzberg, Case Institute of Technology, presiding. The address will be "The Evils of Secrecy" by Harry Woolf, Section L vice president.

Conference on Science Manuscripts. There will be a session for a report on organization and future plans, arranged by Derek J. de Solla Price (Yale University), program chairman, and Carolyn Eisele (Hunter College), local chairman, with Nathan Reingold, Yale University, presiding; 29 Dec.

There will be a meeting of the Council of the Conference on Science Manuscripts and a meeting of the George Sarton Memorial Foundation on 27 Dec.

History of Science Society. Invited papers, joint program of the History of Science Society and the Society for the History of Technology: "Fairly Recent Science and Technology," with Lynn T. White, University of California, Los Angeles, as chairman; 27 Dec. Papers will be presented on Abraham Gottlob Werner's ideas on science and education (Alexander M. Ospovat, University of Oklahoma); the engineering gap between Faraday's discovery of electromagnetic induction and the electric dynamo (Harold I. Sharlin, Polytechnic Institute of Brooklyn); Pierre Gassendi and the physics of Galileo (Joseph T. Clark, Canisius College).

The Society will have its annual dinner, with presentation of the George Sarton medal, on 27 Dec. The dinner will be open to Section L and to members of the Society for the History of Technology.

The first George Sarton memorial lecture will be held 27 Dec., with Henry Guerlac, retiring president of the History of Science Society, presiding and Rene Dubos, Rockefeller Institute, as the speaker. The lecture will be open to the general public.

Invited papers, joint program of the History of Science Society and Section L: "Sociology and Psychology of Scientists," with Thomas S. Kuhn, University of California, Berkeley, as chairman; 28 Dec. Papers will be presented on the scientist's resistance to scientific innovation (Bernard Barber, Columbia University); sources of scientific manpower and competence—some issues for historical and political research (Karl W. Duetsch, Yale University); the psychology of scientists (Anne Roe, Harvard University).

There will be an address by Henry Guerlac and presentation of the Pfizer and Schuman prizes on 28 Dec.

Invited papers: "The Scientific Mainstream," with Duane H. D. Roller, University of Oklahoma, as chairman; 28 Dec. Papers will be presented on the development of analytic methods in chemistry prior to Robert Boyle (Allen G. Debus, Harvard University); a kaleidoscope of appraisals of the importance of Tycho and Kepler (C. Doris Hellman, Pratt Institute); Galen's experiments and clinical observations on circulation and respiration (Rudolph Siegel, University of Buffalo).

A meeting of the editorial board of *Isis,* official journal of the History of Science Society, will be held 28 Dec.

There will be a session for reports on work in progress, with Marshall Clagett, University of Wisconsin, as chairman, on 29 Dec. Papers will be presented on the oral history of contemporary American science (Saul Benison, Columbia University; Galileo's attempt to prove that the earth moves (Harold L. Burstyn, Harvard University); medical alchemy—a study in comparative history (Gerald J. Gruman, Johns Hopkins University); application of the digital computer to the analysis of variant readings of medieval texts (Thomas M. Smith, University of Oklahoma); the role of measurement in the natural philosophy of Galileo and Huygens (W. James King, Smithsonian Institution); the growth of modern science in Japan (Eri Yagi Shizume, Yale University); the teaching of history of science in American colleges (Duane H. D. Roller); the development of atomic models, Kelvin to Bohr (Allan B. Robinson, Harvard University); the impact of mathematics on Goethe and Novalis (Martin Dyck, University of Michigan). The annual business meeting will be held 29 Dec.

Philosophy of Science Association. There will be a report of the secretary-treasurer, Richard L. Meier, University of Michigan, followed by a session entitled "The Boundaries of Systems," with Richard L. Meier as chairman; 29 Dec. Papers will be presented as follows: "The real and the more real: the problem of concrete and analytic systems in the social sciences" (Charles A. McClelland, San Francisco State College) and "Three answers to Pilate: the boundaries of truth" (Garrett Hardin, University of California, Santa Barbara). Karl W. Deutsch, Yale University, will comment on these papers, and there will be a discussion.

Panel, cosponsored by Section L: "Formal Simplicity as a Weight in the Acceptability of Scientific Theories," arranged by Lewis K. Zerby, Michigan State University, with Richard S. Rudner, Michigan State University, as chairman; 30 Dec.

Society for General Systems Research. There will be a session for contributed papers, with Charles A. McClelland, San Francisco State University, as chairman, on 30 Dec.

Invited papers, joint program of the Society for the History of Technology, Section L, and Section M–Engineering: "Nineteenth Century Technology"; 28 Dec. Papers will be presented as follows: "New evaluations in the history of the petroleum industry in the 19th century" (Arnold R. Daum, Northwestern University) and "The British electrical industry in the 19th century: a case of retarded growth" (Thomas P. Hughes, Washington and Lee University). After presentation of the papers, Bern Dibner, Burndy Library, will act as commentator.

An Executive Council meeting and the annual business meeting of the Society will be held on 29 Dec. On the same date there will be a luncheon and presidential address by Lynn T. White, University of California, Los Angeles.

Symposium, joint program of the Society for the History of Technology and Section L: "Automation," with Preston R. Bassett, Ridgefield, Conn., as chairman; 29 Dec. Speakers will be James R. Bright, Harvard University, and John Diebold, New York; A. J. Jaffe, Columbia University, will act as commentator.

Joint session with the American Historical Association: "Technology as Cause in History," with Stanley Pargellis, Newberry Library, Chicago, as chairman; 28 Dec. Papers will be presented as follows: "Technology—neglected clue to historical change" (Roger Burlingame, West Redding, Conn.) and "History—neglected clue to technological change" (Lewis Mumford, University of Pennsylvania). After presentation of the papers, H. Stuart Hughes, Harvard University, will act as commentator.

The Society is also a cosponsor of the two-session symposium, "Patents in the Advancement of Knowledge," sponsored by Section L (see Section L).

Meetings

Biochemical Anthropology

On 6–8 July a group of 24 scientists from three continents gathered at the Fels Research Institute in Yellow Springs, Ohio, for a conference on biochemical anthropology. Under discussion were biochemical differences that have, or may have, adaptive value under particular circumstances. Inevitably the conference, concerned with biochemical polymorphisms in man, overlapped the growing new field of geographical medicine.

Considerable attention was paid to the abnormal hemoglobins, especially where the heterozygote is at an adaptive advantage in malarial areas. Of particular interest were those parts of the world where more than one of the abnormal hemoglobins are present, or where both abnormal hemoglobins and glucose-6-phosphate dehydrogenase deficiency states are coexistent. Of interest, too, were iron requirements in hemolitic disorders having a genetic basis.

Interestingly, discussions on the various serological factors and on the globulin fractions both took a developmental tack. Since maternal-fetal incompatabilities will not arise where the relevant antigen does not develop during prenatal life, "late developing" blood types are obviously at a selective advantage. The ontogenetic timing of other serum fractions may prove useful in phylogenetic comparisons as well, as several participants suggested.

To the anatomists and physical anthropologists present at the conference, the implications currently read into human biochemical polymorphisms proved exceptionally stimulating. Traditionally, morphological variability has been viewed as having no particular significance. Clearly, variability in form and function now suggests either competing directions of selection or a selective advantage associated with heterozygosity.

Mentioned, too, were various "genetic" diseases whose frequency in contemporary populations demands explanation. Here nutritional variables were introduced, as in the interaction between diet and genetic disease. Other immunochemical reactions, chief among them allergies, suggested a fertile field for investigation. Are the disadvantages of being allergic balanced by enhanced resistance to infectious disease?

The meaning of human polymorphisms has emerged only recently as a major area of investigation. Most authors followed Darwin in assuming that polymorphisms exist because they are neutral with respect to natural selection. The conference on biochemical anthropology, aided by the Wenner-Gren Foundation for Anthropological Research, casts new light on this old question. People differ at the molecular level, and in enzyme content and concentration. We are beginning to know why, and we are increasingly able to define the situations that are responsible.

STANLEY M. GARN
Physical Growth Department, Fels Research Institute, Yellow Springs, Ohio

Forthcoming Events

December

1–16. Commission for Climatology, 3rd session, London, England. (World Meteorological Organization, Campagne Rigot, 1, avenue de la Paix, Geneva, Switzerland)

2–5. Central American Medical Conf., 8th, Panama City. (A. Bissot, Departamento de Saud Publica, Ministerio de Trabajo, Prevision Social y Salud Publica, Panama)

3–6. Visual Communications, 4th annual intern. cong., Chicago, Ill. (Visual Communications Cong., 10600 Puritan Ave., Detroit 38, Mich.)

3–8. American Acad. of Dermatology and Syphilology, Chicago, Ill. (R. R. Kierland, First National Bank Building, Rochester, Minn.)

4–6. Spectroscopy, annual southern seminar, Gainesville, Va. (Annual Seminar on Spectroscopy, Univ. of Florida, Gainesville)

4–7. American Inst. of Chemical Engineers, annual, Washington, D.C. (F. J. Van Antwerpen, AICE, 25 W. 45 St., New York 36)

4–9. Radiological Soc. of North America, Cincinnati, Ohio. (D. S. Childs, 713 E. Genesee St., Syracuse 2, N.Y.)

5–7. American Soc. of Agricultural Engineers, winter, Memphis, Tenn. (J. L. Butt, 420 Main St., St. Joseph, Mich.)

5–7. Electronic Industries Assoc., 3rd conf. on maintainability of electronic equipment, San Antonio, Tex. (E. B. Harwood, Office of the Secretary of Defense, Room 3D1018, Pentagon, Washington 25)

5–8. American Rocket Soc., 15th annual, Washington, D.C. (R. L. Hohl, ARS, 500 Fifth Ave., New York 36)

5–8. American Soc. of Agronomy, annual, Chicago, Ill. (L. G. Monthey, ASA, 2702 Monroe St., Madison 5, Wis.)

7–13. American Acad. of Optometry, San Francisco, Calif. (C. C. Koch, 1506–08 Foshay Tower, Minneapolis 2, Minn.)

9–10. The Myocardium—Its Biochemistry and Biophysics, New York, N.Y. (A. P. Fishman, New York Heart Assoc., 10 Columbus Circle, New York 19)

9–11. American Psychoanalytic Assoc., New York, N.Y. (D. Beres, 151 Central Park West, New York 23)

10–11. Academy of Psychoanalysis, New York, N.Y. (J. H. Merin, 125 E. 65 St., New York 21)

11–14. Hot Laboratory and Equipment Conf., 8th, San Francisco, Calif. (J. R. Lilienthal, Los Alamos Scientific Laboratory, P.O. Box 1663, Los Alamos, N.M.)

12–14. American Nuclear Soc. (Isotopes and Radiation Div.), San Francisco, Calif. (O. J. Du Temple, ANS, 86 E. Randolph St., Chicago 1, Ill.)

12–14. Water Pollution, natl. conf., Washington, D.C. (F. A. Butrico, Office of Engineering Resources, Div. of Engineering Services, U.S. Public Health Service, Washington 25)

12–16. Atomic Industrial Forum, conf., San Francisco, Calif. (D. J. Scherer, 3 E. 54 St., New York 22)

13–15. Eastern Joint Computer Conf., New York, N.Y. (E. C. Kubie, EJCC, Computer Usage Co., Inc., 18 E. 41 St., New York 17)

19–20. Statistical Mechanics, conf., London, England. (Organizing Secretary, Physical Soc., 1, Lowther Gardens, London)

22–2. Panamerican Diabetic Congress, 1st, British Honduras. (B. R. Hearst, Director, Diabetic Inst. of America, 55 E. Washington St., Suite 1646, Chicago 2, Ill.)

26–30. Inter-American Cong. of Psychology, 7th, Havana, Cuba. (G. M. Gilbert, Psychology Dept., Long Island Univ., Brooklyn 1, N.Y.)

26–31. American Assoc. for the Advancement of Science, annual, New York, N.Y. (R. L. Taylor, AAAS, 1515 Massachusetts Ave., NW, Washington 5)

27–14. Bahamas Surgical Conf., Nassau. (B. L. Frank, P.O. Box 4037, Fort Lauderdale, Fla.)

27–29. Conference on Strong Interactions, Berkeley, Calif. (A. C. Helmholz, Dept. of Physics, Univ. of California, Berkeley.)

27–29. Northwest Scientific Assoc. and Idaho Acad. of Science, joint meeting, Moscow. (E. J. Larrison, Dept. of Biological Sciences, Univ. of Idaho, Moscow.)

28. Association for Education in International Business, St. Louis, Mo. (J. N. Behrman, Univ. of Delaware, Newark, Delaware)

28–30. American Economic Assoc., St. Louis, Mo. (J. W. Bell, Northwestern Univ., Evanston, Ill.)

28–30. Econometric Soc., St. Louis, Mo. (R. Ruggles, Dept. of Economics, Yale Univ., New Haven, Conn.)

28–29. Linguistic Soc. of America, annual, Hartford, Conn. (A. A. Hill, Box 7790, University Station, Austin 12, Tex.)

28–30. National Council of Teachers of Mathematics, Tempe, Arizona. (M. H. Ahrendt, 1201 16 St., NW, Washington 6, D.C.)

29–31. American Physical Soc., Berkeley, Calif. (K. Darrow, APS, Columbia Univ., 116 St. and Broadway, New York, N.Y.)

January

3–9. Indian Science Cong., 48th session, Roorkee (Uttar Pradesh), India. (General Secretary, ISC Assoc., 64 Dilkhusa St., Calcutta 17, India)

8–12. Thermoelectric Energy Conversion, symp., Dallas, Tex. (P. H. Klein, General Electric Co., Electronics Lab., Bldg. 3, Room 221, Electronics Park, Syracuse, N.Y.)

8–13. American Acad. of Orthopedic Surgeons, Miami Beach, Fla. (J. K. Hart, 116 S. Michigan Ave., Chicago 3, Ill.)

8–14. Bahamas Conf. on Hypertension, Nassau. (I. M. Wechsler, P.O. Box 1454, Nassau)

8–14. International Conf. of Social Work, 10th, Rome. (Miss R. M. William, ICSW, 345 E. 46 St., Room 1012, New York 17)

9–11. Reliability and Quality Control, 7th natl. symp., Philadelphia, Pa. (R. L. Schwerin, ACF Electronics Div., ACF Industries, Inc., 11 Park Place, Paramus, N.J.)

9–12. White House Conf. on Aging, Washington, D.C. (Special Staff on Aging, Office of the Undersecretary, Dept. of Health, Education and Welfare, Washington 25)

9–13. Society of Automotive Engineers, annual, Detroit, Mich. (SAE, 485 Lexington Ave., New York 17)

10–11. Conference on Physics of Polymers, Bristol, England. (Organizing Secretary, Physical Soc., 1 Lowther Gardens, London, S.W.7)

16–18. American Astronautical Soc., annual, Dallas, Tex. (F. F. Martin, AAS, 304 S. Woodstock Dr., Haddonfield, N.J.)

16–19. Instrument Soc. of America, winter instrument-automation conf., St. Louis, Mo. (W. H. Kushnick, 313 Sixth Ave., Pittsburgh 22, Pa.)

22–28. Bahamas Serendipity Conf., 3rd, Nassau. (I. M. Wechsler, P.O. Box 1454, Nassau)

23–25. Institute of the Aeronautical Sciences, 29th annual, New York, N.Y. (Meetings Dept., IAS, 2 E. 64 St., New York 21)

24–27. American Mathematical Soc., 67th annual, Washington, D.C. (J. W. Green, Univ. of California, Los Angeles 24)

24–27. Society for Industrial and Applied Mathematics, Washington, D.C. (G. Kaskey, Remington Rand Univac, 1900 W. Allegheny Ave., Philadelphia, Pa.)

24–27. Society of Plastics Engineers, 17th annual conf., Washington, D.C. (T. A. Bissell, SPE, 65 Prospect St., Stamford, Conn.)

25–27. Mathematical Assoc. of America, annual, Washington, D.C. (H. L. Alder, Dept. of Mathematics, Univ. of California, Davis)

26–27. Western Spectroscopy Conf., 8th annual, Pacific Grove, Calif. (R. C. Hawes, Applied Physics Corp., 2724 S. Peck Rd., Monrovia, Calif.)

27–28. Royal College of Physicians and Surgeons, annual, Ottawa, Ontario, Canada. (T. J. Giles, 150 Metcalfe St., Ottawa)

28–30. Control of the Mind, symp., San Francisco, Calif. (Dept. of Continuing Education in Medicine, Univ. of California Medical Center, San Francisco 22)

29–3. American Inst. of Electrical Engineers, winter meeting, New York, N.Y. (E. C. Day, AIEE, Technical Operations Dept., 33 W. 39 St., New York 18)

30–3. Clinical Cong. of Abdominal Surgeons, Miami Beach, Fla. (B. F. Alfano, 663 Main St., Melrose 76, Mass.)

30–4. American Library Assoc., midwinter meeting. (Mrs. F. L. Spain, New York Public Library, 20 W. 53 St., New York, N.Y.)

31–4. American Assoc. of Physic Teachers, New York, N.Y. (F. Verbrugge, 135 Main Engineering, Univ. of Minnesota, Minneapolis)

31–4. American Physical Soc., annual, New York, N.Y. (K. Darrow, APS, Columbia Univ., 116th St. and Broadway, New York)

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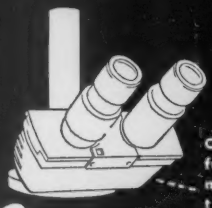
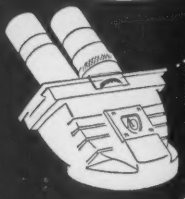
Microstar's Building Block Concept of design, exclusive with AO Spencer, lets you add parts as new needs arise.

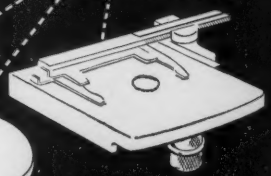
Special inclined monocular and vertical monocular bodies available. 35 mm camera for crisp inexpensive photomicrography. Coupled system lets you shoot what you see.



Choice of 3 interchangeable full 360° rotatable bodies, monocular, binocular and trinocular; inclined for comfort.



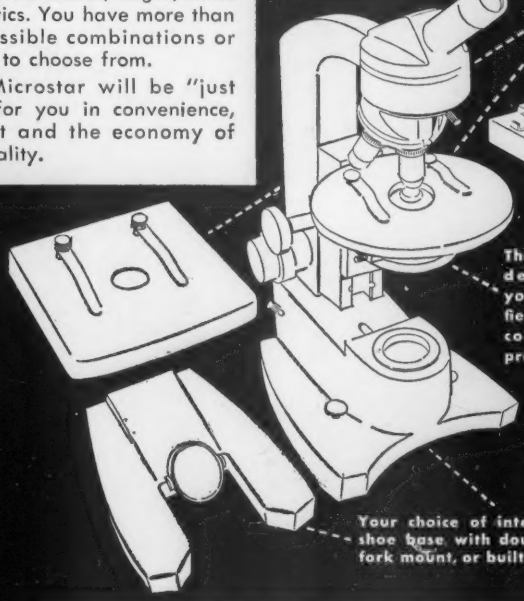
Focus the stage and the specimen to the objectives with low positioned coarse and fine adjustments. Choose from 3 interchangeable stages; graduated or ungraduated mechanical stages or the new Micro-Glide circular stage.



No other microscope can offer you such a wide choice of interchangeable parts and accessories.

You can adapt the Microstar to your exact needs with various combinations of readily interchangeable bodies, stages, bases and optics. You have more than 600 possible combinations or models to choose from.

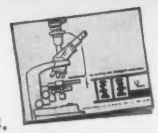
Your Microstar will be "just right" for you in convenience, comfort and the economy of real quality.



The large fork-type condenser mount allows you to interchange bright-field, phase and dark field condensers quickly and precisely.

Your choice of interchangeable horse-shoe base with double-plano mirror in fork mount, or built-in base illuminator.

Write Dept. M-3 for your copy of the complete Microstar story. Ask for BROCHURE SB124.



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American Optical Company

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